Chapter 11
Human Health

Contents

11. Human Health

11.1 Introduction

This Chapter of the Environmental Impact Assessment Report (EIAR) has considered the potential human health impacts associated with the Construction and Operational Phases of the Lucan to City Centre Core Bus Corridor Scheme (hereafter referred to as the Proposed Scheme).

The World Health Organization (WHO) Constitution, which came into force in 1948, defines health as *'a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity'* (WHO 1948). This assessment, therefore, includes consideration of potential impacts of the Proposed Scheme on physical, mental and social aspects of health.

Human health is interrelated to several other environmental issues assessed in this EIAR. Therefore, this Chapter is supported by, and should be read in conjunction with the following EIAR Chapters:

- Chapter 6 (Traffic & Transport);
- Chapter 7 (Air Quality);
- Chapter 8 (Climate);
- Chapter 9 (Noise & Vibration);
- Chapter 10 (Population);
- Chapter 13 (Water); and
- Chapter 14 (Land, Soils, Geology & Hydrogeology).

The assessment has been carried out according to best practice and guidelines relating to human health, and in the context of similar large-scale transport infrastructural projects.

The aim of the Proposed Scheme when in operation is to provide enhanced walking, cycling and bus infrastructure on this key access corridor in the Dublin region, which will enable and deliver efficient, safe, and integrated sustainable transport movement along the corridor. The objectives of the Proposed Scheme are described in Chapter 1, Introduction. The Proposed Scheme, which is described in Chapter 4 (Proposed Scheme Description), has been designed to meet these objectives.

The design of the Proposed Scheme has evolved through the application of a comprehensive design iteration process with particular emphasis on minimising the potential for environmental impacts where practicable whilst ensuring the objectives of the Proposed Scheme are maintained. In addition, feedback received from the comprehensive consultation programme undertaken throughout the option selection and design development programme have been incorporated where appropriate.

11.2 Methodology

Health is determined by a complex interaction between individual characteristics, lifestyle and the physical, social and economic environment. Most public health experts agree that these 'wider determinants of health' are more important than formal healthcare for ensuring a healthy population (Braveman and Gottleib 2014). Image 11.1 provides a widely cited illustration of the wider determinants of health.

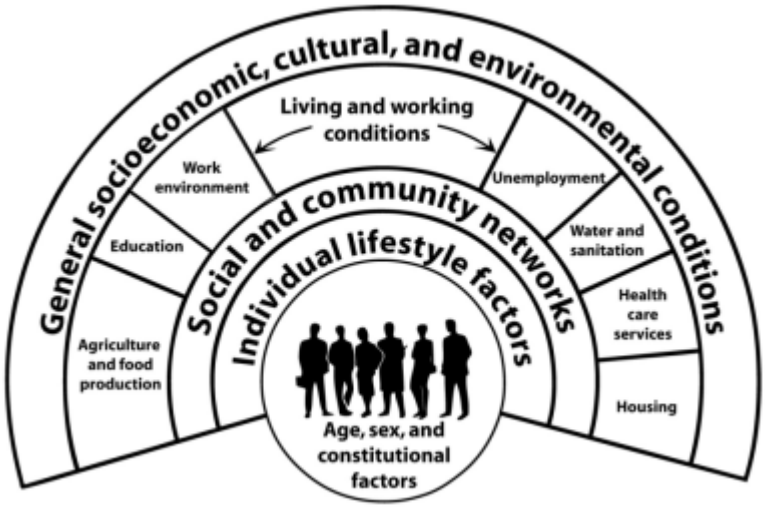


Image 11.1: Social Determinants of Health (Dahlgren and Whitehead 1991)

A related issue, of key importance to public health, is the issue of social inequalities of health, which are *'the unfair and avoidable differences in health status across groups in society',* which result from the uneven distribution of wider determinants (WHO *n.d.*). The Marmot Review into health inequalities (Marmot 2010), looked at differences in health and well-being between social groups and described how the social gradient on health inequalities is reflected in the social gradient on educational attainment, employment, income, quality of neighbourhood and other issues. Addressing the wider determinants of health is seen as an important means of tackling social inequalities of health and improving population health, as a whole.

The aim of this assessment is therefore to identify the wider determinants of health that would likely be affected by the Proposed Scheme and how these impacts are associated with health outcomes.

11.2.1 Study Area

A study area covering approximately 500m (metres) on each side of the centreline of the Proposed Scheme has been selected (please refer to Figure 11.1 in Volume 3 of this EIAR). This size of study area captures the main communities within a distance most likely to be affected by the Proposed Scheme (for example this distance captures people who live and work within easy access of the Proposed Scheme and also encompasses the air quality and noise study areas). The study area has been identified by including all the Small Areas that touch or coincide with the 500m study area from the Proposed Scheme boundary. Small Areas are areas of population generally comprising between 80 to 120 dwellings. They were developed by the National Institute of Regional and Spatial Analysis on behalf of the Ordnance Survey Ireland and in consultation with the Central Statistics Office (CSO). They were designed as the lowest geographical level for the compilation of statistics, in line with data protection, and generally comprise either complete or a part of towns or neighbourhoods.

11.2.2 Relevant Guidelines, Policy and Legislation

Directive 2014/52/EU of the European Parliament and of the Council of 16 April 2014 amending Directive 2011/92/EU on the assessment of the effects of certain public and private projects on the environment (hereafter referred to as the 2014 EIA Directive) introduced 'human health' as a factor to be considered in Environmental Impact Assessment (EIA).

The preparation of this assessment has had regard to the following guidelines and policy documents:

- International Association for Impact Assessment (IAIA) and European Public Health Association (EUPHA) Human Health: Ensuring a High Level of Protection. A reference paper on addressing Human Health in Environmental Impact Assessment (hereafter referred to as the IAIA and EUPHA Guidance) (IAIA and EUPHA 2020)
- Health Impact Assessment in Planning (IEMA 2020);

- Healthy Ireland - A Framework for Improved Health and Wellbeing 2013 – 2025 (the Healthy Ireland Framework) (Department of Health 2019);
- Environmental Noise Guidelines for the European Region (hereafter referred to as the WHO Noise Guidelines) (WHO 2018);
- Environmental Impact Assessment of Projects. Guidance on the Preparation of the Environmental Impact Assessment Report (European Commission 2017);
- Environmental Protection Agency (EPA) Guidelines on the Information to be Contained in Environmental Impact Assessment Reports (hereafter referred to as the EPA Guidelines) (EPA 2022);
- Health in Environmental Impact Assessment – A Primer for a Proportionate Approach (Cave *et al.* on behalf of Institute of Environmental Management and Assessment (IEMA)) (hereafter referred to as the IEMA Primer) (IEMA 2017);
- United States (US) EPA Health Impact Assessment Resource and Tool Compilation (US EPA 2016);
- Institute of Public Health in Ireland (IPH) Health Impact Assessment Guidance (IPH 2009);
- Health Impact Assessment Guidance for Ireland and Northern Ireland (IPH 2021);
- Air Quality Guidelines Global Update 2005. Particulate Matter, Ozone, Nitrogen Dioxide and Sulfur Dioxide (hereafter referred to as the WHO Air Quality Guidelines) (WHO 2005); and
- WHO Global Air Quality Guidelines: Particulate matter ($PM_{2.5}$ and PM_{10}), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide (WHO 2021).

The European Commission's Guidance on the Preparation of the Environmental Impact Assessment Report notes that *'human health is a very broad factor'* that is *'highly project dependent'*. It states that:

> '*The notion of human health should be considered in the context of the other factors in Article 3(1) of the EIA Directive and thus environmentally related health issues (such as health effects caused by the release of toxic substances to the environment, health risks arising from major hazards associated with the Project, effects caused by changes in disease vectors caused by the Project, changes in living conditions, effects on vulnerable groups, exposure to traffic noise or air pollutants) are obvious aspects to study.*' (European Commission 2017)

This assessment recognises that human health is interrelated with several other environmental factors. The assessment has sought to identify the potential changes to emissions, health risks, the built environment and traffic that could be caused by the Proposed Scheme, and how these changes may in turn be associated with health outcomes.

The EPA Guidelines state that:

> '*The evaluation of effects on these pathways is carried out by reference to accepted standards (usually international) of safety in dose, exposure or risk. These standards are in turn based upon medical and scientific investigation of the direct effects on health of the individual substance, effect or risk. This practice of reliance upon limits, doses and thresholds for environmental pathways, such as air, water or soil, provides robust and reliable health protectors [protection criteria] for analysis relating to the environment.*' (EPA 2022)

This assessment has therefore taken account of the relevant guidelines on limit values and thresholds which are listed in Chapter 7 (Air Quality), Chapter 9 (Noise & Vibration), Chapter 13 (Water) and Chapter 14 (Land, Soils, Geology & Hydrogeology). The assessment draws on the findings of other chapters within this EIAR (see Section 11.1 'Introduction' for a list of relevant chapters).

In 2017, IEMA published the IEMA Primer. The document advocates for a proportionate assessment of health impacts within the EIA process and suggests what should be assessed in this context. Consideration has been given to the general approach put forward in the IEMA Primer when preparing this Chapter. The IEMA Primer notes that Health Impact Assessment (HIA) and EIA are separate processes and that whilst a HIA can inform EIA practice in relation to human health, a HIA alone will not necessarily meet the EIA human health requirement. HIA is not routinely carried out for major infrastructure projects in Ireland.

The Health Impact Assessment Guidance for performing HIA, was issued by the IPH in 2009. The Health Impact Assessment Guidance notes that '*HIA derives its approach and framework from EIA but was developed partly as a consequence of EIA not placing sufficient emphasis on human health*'. In fact, the introductory text in the original Council Directive 85/337/EEC of 27 June 1985 on the assessment of the effects of certain public and private projects on the environment makes it clear that there was intention that EIA was designed to address human health impacts, even though this intention was somewhat lost in transposition to member state legislation. The revised wording in the 2014 EIA Directive makes the requirement to consider human health explicit, in an attempt to address the gaps in EIA practice which HIA had sought to fill. The IPH issued revised HIA guidance (Health Impact Assessment Guidance for Ireland and Northern Ireland) in November 2021. This guidance states that '*HIA can be done as a standalone assessment, or health outcomes can be considered as part of environmental assessments, such as …Environmental Impact Assessment (EIA)*' (IPH 2021). The IEMA Primer notes that the WHO provides an overview of health in different types of impact assessment and presents the WHO perspective on the relationship of HIA to other types of impact assessment as follows:

> '*The health sector, by crafting and promoting HIA, can be regarded as contributing to fragmentation among impact assessments. Given the value of impact assessments from a societal perspective, this is a risk not to be taken lightly ... The need … and justification for separate HIA cannot automatically be derived from the universally accepted significance of health; rather, it should be demonstrated whether and how HIA offers a comparative advantage in terms of societal benefits …*
>
> *Health issues can, and need to, be included [in impact assessment] irrespective of levels of integration. At the same time, from a civic society perspective, it would be unacceptable for HIA to weaken other impact assessments. A prudent attitude suggests optimizing the coverage of health along all three avenues:*
>
> - *better consideration of health in existing impact assessments other than HIA;*
> - *dedicated HIA; and*
> - *integrated forms of impact assessment*'.

It is clear, therefore, that even the WHO does not support a stand-alone HIA, unless it could be demonstrated to be of advantage over the EIAR. It is for these reasons, that this health assessment is part of the EIAR and there is not a stand-alone HIA.

HIA is defined as a combination of procedures, methods and tools that systematically judges the potential, and sometimes unintended, effects of a policy, plan, programme or project on both the health of a population and the distribution of those effects within the population. Whereas the health assessment in the context of EIA focuses the attention of the assessment on likely significant effects (i.e. on effects that are deemed likely to occur and, if they were to occur, would be expected to be significant (as per the requirements of the 2014 EIA Directive)). The IPH Health Impact Assessment Guidance refers to different levels of HIA depending on factors such as the complexity of the project, potential scale and severity of health impacts and quality of evidence. The levels of HIA vary from desktop HIA (using readily available data), rapid HIA to comprehensive HIA (involving in depth investigation). The approach applied to this assessment draws on guidance for desktop HIA but applies it to meet the EIA population and human health assessment requirement.

The most developed guidance on assessing health in EIA, to date, is the IAIA and EUPHA Guidance, issued in December 2020. This has informed the approach to assessing significance, an important requirement of EIA, which is discussed in Section 11.2.4.

In terms of policy, Healthy Ireland – A Framework for Improved Health and Wellbeing 2019 – 2025 (hereafter referred to as the Healthy Ireland Framework) (Department of Health 2019) provides a roadmap for building a healthier Ireland. The policy framework is based around the following four goals:

- To increase the proportion of people who are healthy at all stages of life;
- To reduce health inequalities;
- To protect the public from threats to health and wellbeing; and
- To create an environment where every individual and sector of society can play their part in achieving a healthy Ireland.

The Healthy Ireland Framework recognises the importance of intersectoral collaboration (for example involving the health, transport, education, planning, business sectors) to address the social, environmental and economic determinants of health required for health improvement and protection. This assessment has, therefore, taken account of the policy goals when considering the potential significance of the Proposed Scheme in terms of health promotion, reducing health inequalities, health protection, and creating an environment that supports a healthy society.

Taking into account the broad range of health outcomes associated with noise, WHO Europe prepared the WHO Noise Guidelines (WHO 2018). The WHO Noise Guidelines include a recommendation that average daytime road traffic noise exposure should be reduced to below 53dB L_{den} (i.e. the 24-hour noise rating level) and that night-time traffic noise exposure should be below 45dB L_{night} (i.e. the long-term average sound level over the night periods of a year, with the eight-hour night-time period between 23:00hrs and 07:00hrs) (WHO 2018). It is noteworthy that WHO Europe provides the rationale for these guideline levels. The 53 dB L_{den} level is based on the annoyance criteria rather than serious health effects. In fact, the WHO Noise Guidelines suggest that, if a level was being set on cardiovascular criteria alone, the level would likely be in the order of 59.3 dB L_{den}. In terms of how this is actually calculated, it is conservatively calculated at the level of noise that may be associated with a 5% increase in relative risk of a cardiovascular event (WHO 2018). For the vast majority of people, the absolute risk of a cardiovascular event in the next year is less than 1%. For an individual who has that risk of 1%, even allowing for the worst exposure to traffic noise effects, the risk is 1.05%. The difference is therefore imperceptible on an individual basis. It is a far less significant impact than other risk factors, which is the reason that it is not considered one of the risk factors when calculating an individual's cardiovascular risk. However, when this risk is applied across a large population, such as the population of Europe, even small changes can make a significant difference. This explains why the WHO Noise Guidelines are applicable for populations but not for individuals. The 45 dB L_{night} level is based on sleep disturbance but is somewhat conservative since this level represents only 3% of the population self-reporting as highly sleep disturbed (WHO 2018). To put this further in context, even at levels of 55 dB L_{night}, the percentage of people self-reporting sleep disturbance is still only 6% (WHO 2018).

The WHO Noise Guidelines specifically state that:

> *'to reduce health effects, the GDG (Guideline Development Group) strongly recommends that policymakers implement suitable measures to reduce noise exposure from road traffic in the population exposed to levels above the guideline values for average and night noise exposure. For specific interventions, the GDG recommends reducing noise both at the source and on the route between the source and the affected population by changes in infrastructure.'*

The guidelines are conservative and are not environment-specific. The Proposed Scheme will operate in an urban traffic environment and the guidelines therefore must be reconciled with the existing baseline. In carrying out this exercise, the assessment in this Chapter recognises that these guidelines were drafted with an abstract population in mind. The WHO readily acknowledges that the WHO Noise Guidelines cannot be reasonably achieved at every individual residence. However, the question in relation to the assessment of the impact on health will be determined by the overall impact on the population. Where it is demonstrated that the Operational Phase would have an overall positive effect on population due to environmental noise, the public transport development would be in keeping with the WHO Noise Guidelines.

The WHO has prepared Air Quality Guidelines, which were updated in September 2021. The WHO has recommended guideline levels for annual and short-term exposure for various air pollutants. Some of these are more conservative than the EU Limits set. However, the WHO has also set recommended interim targets to:

> '*serve as incremental steps in the progressive reduction of air pollution towards the air quality guideline levels and are intended for use in areas where air pollution is high. In other words, they are air pollutant levels that are higher than the air quality guideline levels, but which authorities in highly polluted areas can use to develop pollution reduction policies that are achievable within realistic time frames. The interim targets should be regarded as steps towards ultimately achieving air quality guideline levels, rather than as end targets.*' (WHO, 2021).

11.2.3 Data Collection and Collation

Spatial statistical data relating to the population within the study area have been obtained from the CSO.

Further information on health profiles and health research have also been obtained from publicly available sources, including those produced by Lenus – a central source for open access health research in Ireland (Lenus 2021), the Health Service Executive (HSE) and the IPH. Evidence for associations between health outcomes and certain determinants has been drawn from a wide range of published health literature and is referenced throughout the assessment.

Health data used to inform this assessment are generally 'at population level' rather than clinical level. Since the assessment is reliant on aggregated data for the at population level, it cannot be used to infer potential impacts on health outcomes at individual (clinical) levels.

11.2.4 Appraisal Method for the Assessment of Impacts

The assessment has been undertaken in the following stages:

11.2.4.1 Develop Baseline Understanding of Population Health Profiles and Determinants of Health

A desk study of the available data has been undertaken to identify the populations of interest and characterise them in terms of their population size, socio-economic status, burden of disease and the distribution of those existing factors.

Baseline data from the assessments of other chapters in this EIAR was then reviewed to understand baseline determinants of health. Issues such as the location and distribution of services and community amenities were obtained from Chapter 10 (Population). Information on air pollution levels and existing noise was obtained from Chapter 7 (Air Quality) and Chapter 9 (Noise & Vibration), respectively. Other relevant information, such as traffic and travel patterns, was obtained from Chapter 6 (Traffic & Transport). These were considered the most relevant aspects of the environment to understand in terms of human health. However, there is an interaction between human health and several other environmental topics assessed (refer to Chapter 21 (Cumulative Impacts & Environmental Interactions), Section 21.4.3 for further information).

The purpose was to build up a baseline understanding of where the health-related environmental and social issues may be and the characteristics of the communities affected, to enable an assessment as to whether these could be exacerbated or relieved by the Proposed Scheme.

11.2.4.2 Identification of Potential Impacts

The characteristics of the Proposed Scheme have been considered and the potential pathways between aspects of the construction and operation of the Proposed Scheme and health outcomes (beneficial and adverse) have been mapped out. Image 11.2 presents several pathways to health outcomes from transport policies and projects. Due to the nature of impacts on human health, many of these are indirect. The assessment of the Operational Phase of the Proposed Scheme has focused on those potential impacts most likely to be influenced by the Proposed Scheme, namely air quality, noise, community severance, social use of outdoor space, physical activity levels, access and risk of injuries. For the identification of construction impacts, reference has been made to the other environmental topic assessments to identify the aspects of the environment likely to be affected, and then a further consideration has been made as to whether there is a likely pathway between those impacts and human health outcomes.

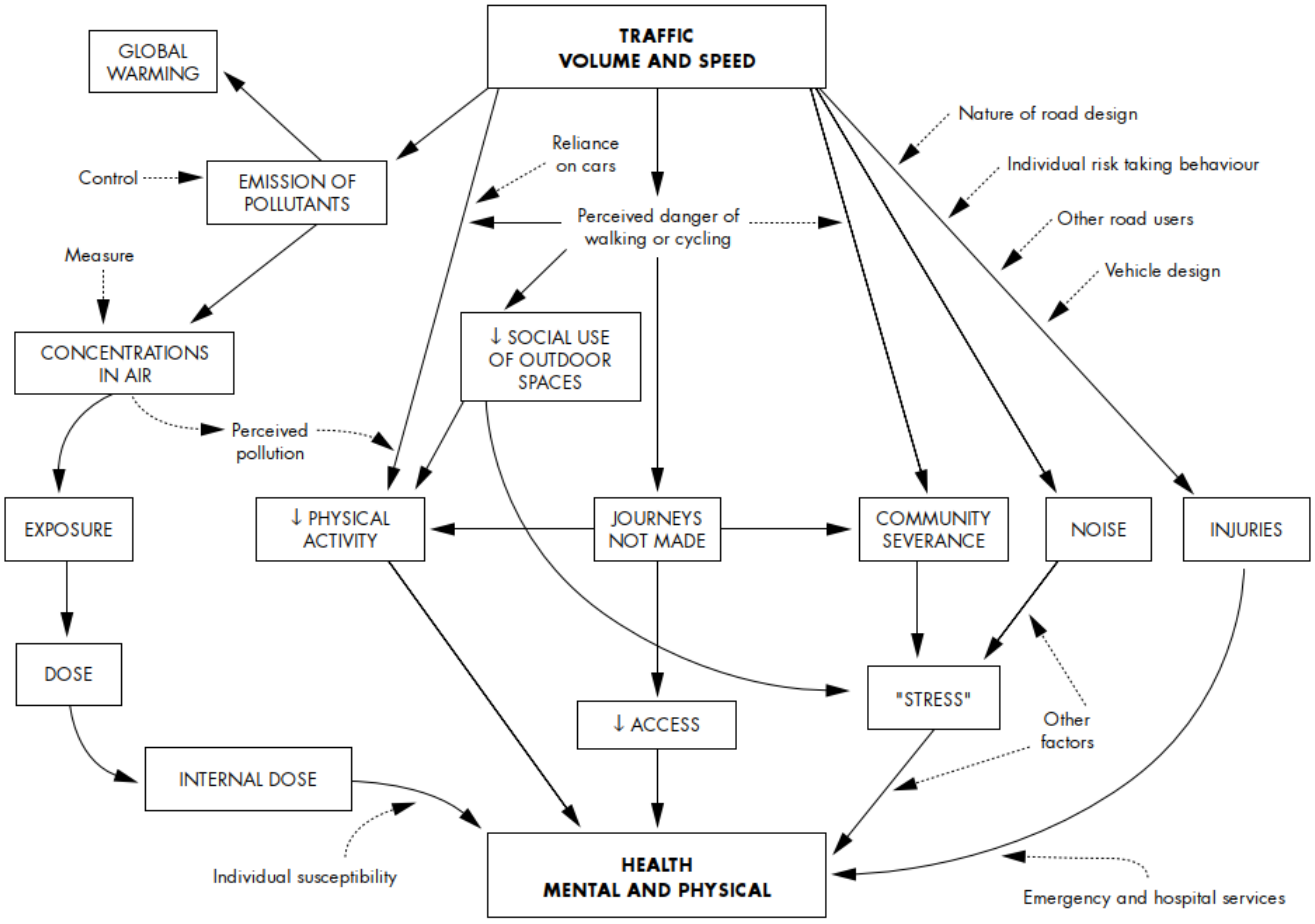


Image 11.2: Pathways from Transport Policy to Health Outcomes (Joffe and Mindell 2002)

11.2.4.3 Literature Review

A literature review was undertaken to identify the strength of evidence for associations between impacts on various determinants of health and health outcomes. The issues targeted for the literature review related to the mapping out of potential health impact pathways above. The literature review has critically evaluated the evidence and whether the evidence is substantial, weak or speculative. The review has taken into account, whether the available research is likely to be generalisable to the populations in the study area for the Proposed Scheme. The literature review has been important in supporting the assessment with the best available evidence. The results of the literature review are integrated in the reporting of the baseline and assessment of this Chapter, rather than presented as a standalone section, so that the findings are presented within the context of the assessment for the Proposed Scheme. Full references for the sources of research consulted are provided in Section 11.7.

11.2.4.4 Assessment of Impacts

The assessment has considered the potential influence of the Proposed Scheme in terms of health protection, health promotion and health inequalities. The assessment describes how the Proposed Scheme could impact on baseline environmental and social factors (determinants of health), whether these impacts are associated with health outcomes (using evidence from the literature review), and whether those outcomes are considered to be positive or negative.

The reporting of impacts has taken a descriptive approach so that the evidence and assumptions underpinning the judgement of significance can be explained. The judgement of sensitivity, magnitude and significance takes into account several factors, including:

- Health status of the population;

- Social inequalities;
- Likely level of exposure to a health risk;
- Likely size of population affected;
- Level of evidence in scientific literature for an association between an environmental impact and health outcomes; and
- Existing health policy and priorities.

These considerations have been developed with regard to the IAIA and EUPHA Guidance (IAIA and EUPHA 2020).

Where appropriate, the assessment has taken account of evidence for dose-response relationships to certain pollutants (i.e. air pollution) and the likely duration of exposure to those pollutants, using information from the relevant assessment chapters in this EIAR, as well as from the literature review. Since health evidence normally underpins the limits set for certain pollutants (e.g., air quality objectives), it can be determined that significant effects on human health are not likely, provided that these limits are not exceeded.

Table 11.1 sets out the criteria used to guide the description of significance for health impacts, after considering the range of issues described above. These criteria have been aligned to terminology for level of significance set out in the EPA Guidelines (EPA 2022).

Table 11.1: Significance Criteria for Health Impacts

Impact Level	Significance Criteria
Imperceptible	The Proposed Scheme will have an impact on a determinant of health of a type and degree which is not associated with any population health outcomes.
Not Significant	The Proposed Scheme will have an impact on a determinant of health of a type and degree where no health outcomes are attributable. Example considerations for assigning this level of significance are: • Level of exposure to impact is sufficiently low to pose no likelihood of developing an associated health outcome.
Slight	The Proposed Scheme will have an impact on a determinant of health of a type and degree where there may be a small impact on individual reported symptoms but no change in population health status can be attributed. Example considerations for assigning this level of significance include whether: • The level of risk of developing a health outcome attributed to impact is extremely low (for example where there is limited and inconsistent evidence for an association with a health outcome, or the risk of exposure to impact is very unlikely, or the level of risk attributed to the impact is very low compared to other factors); • Associated health outcomes are mild, temporary and reversible; • People affected are not sensitive and can readily avoid or adapt to impact, or impact can be readily mitigated, with no effect on quality of life beyond the short-term.
Moderate	The Proposed Scheme will have an impact on a determinant of health of a type and degree where there may be a noticeable impact on individual health status but no change to population morbidity or mortality is attributable. Example considerations for assigning this level of significance include whether: • There is some scientific evidence of association between the impact and population health outcomes; • The degree of population health impact is consistent with current health trends; • Associated health outcomes are reversible and/or can be managed or mitigated; • No effect on quality of life is anticipated beyond the short-term; • No change in morbidity or mortality can be attributed to the Proposed Scheme.
Significant	The Proposed Scheme will have an impact on a determinant of health of a type and degree where there may be a significant impact on individual health status (such as change in morbidity or mortality risk) but no measurable change to population morbidity or mortality is likely. Example considerations for assigning this level of significance include whether: • There is a strong body of scientific evidence for a clear association between the impact and population health outcomes; • The impact has the potential to have a measurable effect on the health status of some individuals with an associated change in morbidity and/or mortality (i.e. there is a risk of exposure to impact which is likely to be restricted to small numbers of individuals but the health consequences could be affect health status); • The impact may influence health inequalities at a population level.
Very Significant	The Proposed Scheme will have an impact on a determinant of health of a type and degree where there may be a significant impact on the health status (such as change in morbidity or mortality risk) of groups of people within a community. Example considerations for assigning this level of significance include whether: • There is a strong body of scientific evidence for a clear association between the impact and population health outcomes; • The impact has the potential to have a measurable effect on the health status of groups of people (for example where exposure to impact is likely to be subject to specific geographic locations, lifestyle choices, social circumstances or health characteristics not widely experienced in a community); • The impact is likely to influence health inequalities within some groups.
Profound	The Proposed Scheme will have an impact on a determinant of health of a type and degree where there may be a significant impact on the health status (such as change in morbidity or mortality risk) of communities of people. Example considerations for assigning this level of significance include whether: • There is a strong body of scientific evidence for a clear association between the impact and population health outcomes; • The exposure to the impact has the potential to be widespread and affect the health status of communities; • The impact is likely to influence health inequalities at a community level.

An example of how these criteria are applied could be with the health outcome of asthma. An Imperceptible impact would be one with no measurable effect on asthma. A Slight impact might be a likelihood where a temporary increase in symptoms in an individual could be associated, but there would be no likely change in the severity of the underlying condition or no treatment required. A Moderate impact might be a likelihood of an individual increasing their use of inhalers, which is attributable to the Proposed Scheme, but there would be no change in underlying condition and no effect on the vast majority of asthmatics. A Significant impact might be a likelihood of

an individual becoming asthmatic or an individual's asthma becoming measurably more severe as a result of the impacts of the Proposed Scheme. A Very Significant impact might be a likelihood of a group of individuals becoming asthmatic or their asthma becoming measurably more severe as a result of impacts from the Proposed Scheme. A Profound impact might be a likelihood of measurable increase in the incidence or severity of asthma in a community as a result of the impacts of the Proposed Scheme.

11.2.4.5 Mitigation

Using evidence from the literature review, as well as professional knowledge and experience, recommendations for mitigation have been put forward to help limit pathways to adverse effects and, where feasible, to promote positive health outcomes.

11.2.4.6 Mental Health and Wellbeing

During the planning process stage of a Proposed Scheme, potential adverse effects on mental health are often mentioned, for example, anxiety and stress experienced by those whose lands are to be compulsorily acquired, or those who will experience a change in the environment in which they live.

The community may also experience annoyance from the temporary impacts of traffic management and other effects during the Construction Phase. In contrast, there is the potential reduction in annoyance amongst bus users in the Operational Phase where journey times will be reduced and journey reliability increased. Annoyance among cyclists and pedestrians will also potentially reduce in the Operational Phase as facilities are improved. Annoyance, however, is not in itself a health effect.

For virtually every proposal, especially for one like Proposed Scheme, there are concerns about potential adverse effects on a person's overall psychological wellbeing. This is somewhat a more difficult matter to assess as there are no direct measurements that can be used. While one can give great detail in predicting, for example noise emissions, one cannot use the same scientific certainty in predicting psychological impacts. It is not possible to use a standards-based approach, for example.

There are various degrees of psychological impact and these can be both positive and negative. There can be a positive impact, whereby people may look forward to better and more reliable public transport or improved cycling experiences. There can also be negative effects of varying degrees. At the lower end of this impact might be annoyance where, for example, somebody is annoyed by outside noise, dust depositing or temporary traffic delays associated with construction activities. This is not a medically defined health effect. However, if someone develops a psychological illness such as anxiety or depression, this would be a medically defined health effect.

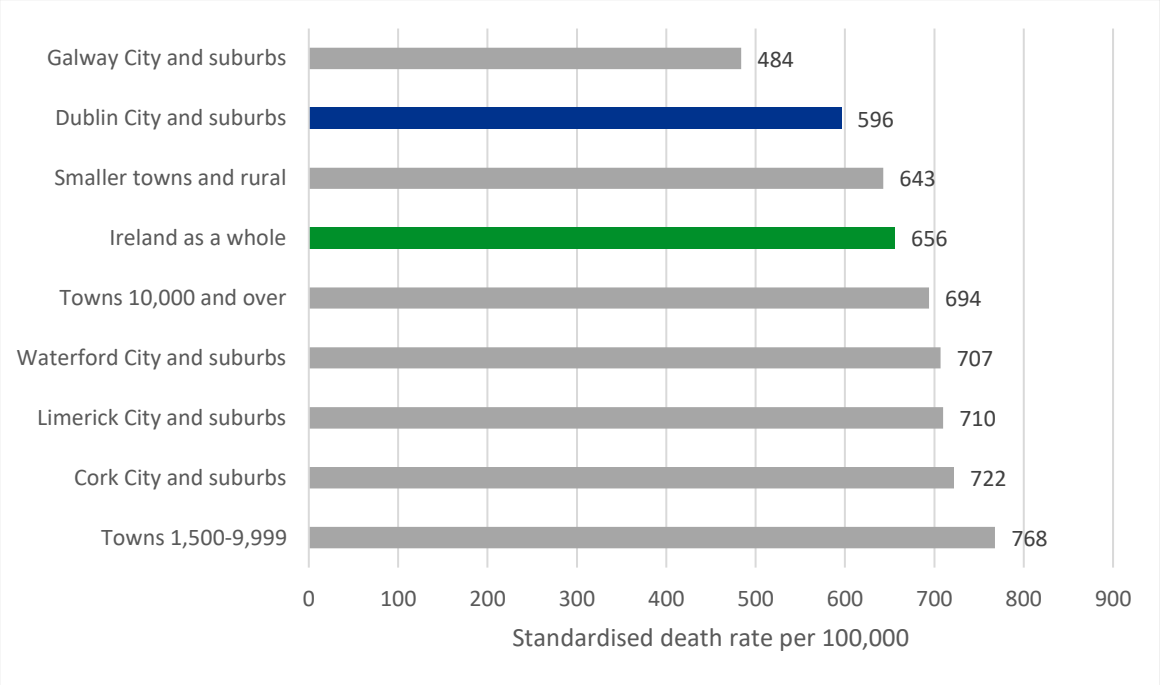
Construction by its very nature is transient but it is expected that construction activities will cause some annoyance such as from road diversions and temporary lane closures. The potential effects will be minimised by use of appropriate traffic management and avoidance of extended night-time closures. There has been a considerable amount of construction, including somewhat similar projects such as Luas projects in Ireland over the last few decades. However, there is no documented evidence from these projects to link adverse outcomes with psychological health in Ireland.

This understanding of potential issues of mental health and wellbeing has helped to inform the judgement of significance of impacts.

11.3 Baseline Environment

11.3.1 General Health

The population of Dublin City and its suburbs has a lower mortality rate than Ireland as a whole, and is notably lower than the other major cities in Ireland, with the exception of Galway (refer to Graph 11.1).

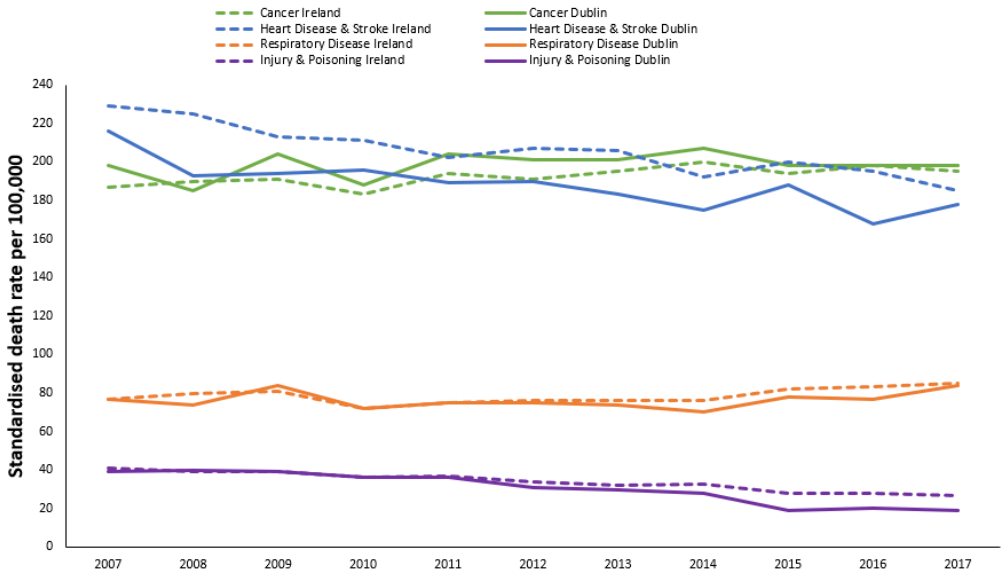


Graph 11.1: Standardised Death Rate (SDR) per 100,000 for Dublin, Compared to Other Regions 2016 - 2017 (CSO 2019a)

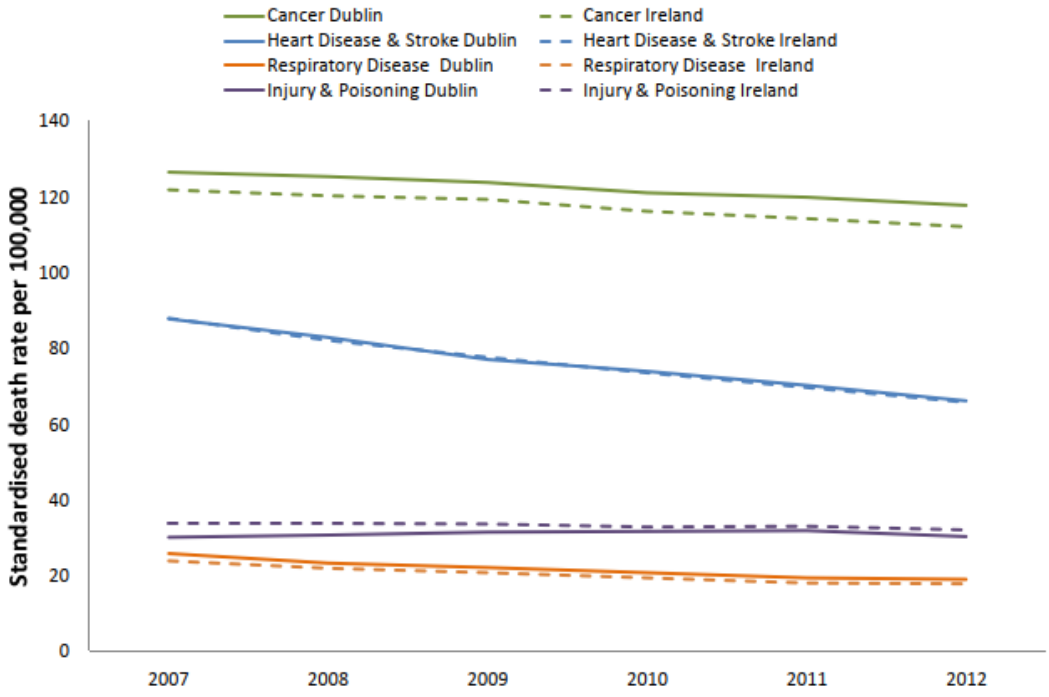
Approximately half of the Proposed Scheme falls within the jurisdiction of South Dublin County Council (SDCC), while the other half falls within Dublin City Council (DCC). In addition, the north-west part of the study area falls within Fingal County Council (FCC) (refer to Figure 11.1 in Volume 3 of this EIAR). The 2015 health profiles (HSE 2015a; HSE 2015b and 2015c), which are the most recent available at the time of writing, for each of these three county council areas have been used to inform the baseline. However, accurate health information on issues such as obesity and chronic disease are only available at city and county level combined.

The four principal causes of death in Dublin and Ireland for all ages are heart disease and stroke (circulatory disease), cancer (all types), respiratory disease, injury, and poisoning. As can be seen on Graph 11.2, there has been a general decline in rates of heart disease and stroke, and injury and poisoning during the 10 year period between 2007 to 2017, while there is no clear trend for cancer or respiratory disease.

In terms of premature death (i.e. deaths of people under 75 years), only data for 2007 to 2012 have been identified specifically covering the Dublin area. Cancer was the leading cause, followed by heart disease and stroke, injury and poisoning (which includes suicide) and respiratory disease (refer to Graph 11.3) (CSO 2018). The data show a declining trend across these causes between 2007 and 2012, with the exception of injury and poisoning which had a slight upward trend in Dublin from 2007 to 2011. This may reflect the influence of suicide within this category of cause of death and an association with the post-2008 Irish economic downturn. As with all ages, death rates from cancer in Dublin are higher than the national average.



Graph 11.2: Trends in Dublin's Death Rates per 100,000 for the Four Principal Causes of Death (2007 - 2017) for All Ages Compared to Ireland (Data for City and County Area) (CSO 2018)



Graph 11.3: Trends in Dublin's Death Rates per 100,000 for the Four Principal Causes of Death (2007 - 2012) for Under 75 Years (Premature Mortality) Compared to Ireland (Data for City and County Area) (CSO 2018)

Table 11.2 and Table 11.3 outline the key facts according to the HSE health profiles for Dublin South and Dublin City.

Table 11.2: South Dublin Health Profile Key Facts (HSE 2015a)

Dublin South Health Profile Key Facts
Dublin South has: • A lower proportion of the population (8.7%) aged over 65 years than the national rate (11.7%); • The highest percentage of lone parent households at 13.8% (national rate is 10.9%) and above average number of households which are local authority rented at 10.2% (national rate is 7.8%); • Above average birth rates at 18.8% (national rate is 15.8%) and a breast feeding rate of 53.7% (national rate is 46.6%); • Cancer incidence rates above the national rate for male colorectal cancer and female malignant melanoma and male and female lung cancers; and • Mortality rates that are above the national average for heart disease and stroke in those aged under 65 years.

Table 11.3: Dublin City Health Profile Key Facts (HSE 2015b)

Dublin City Health Profile Key Facts
Dublin City has: • A dependency ratio of 38.4% (i.e. those aged 0 to 14 years and 65 years and over as a proportion of those aged 15 to 64 years) which is lower than the national rate of 49.3%; • A high level of households which are local authority rented at 11.5% (national 7.8%); • A diverse population with 21.3% of the population who are not white Irish; • A higher than average number of persons who report their health as being bad or very bad at 2% (national rate at 1.5%) or who have a disability 14.9% (national rate at 13%); • A greater than average birth per 1,000 rate for those aged under 20 at 19% (national rate 12.3%); • Cancer incidence rates above the national rate for male colorectal cancer and female malignant melanoma and male and female lung cancers; and • Mortality rates that are above the national average for heart disease and stroke in those aged under 65 years.

Table 11.4: Fingal County Health Profile Key Facts (HSE 2015c)

Fingal County Health Profile Key Facts
Fingal County has: • A dependency ratio of 46% (i.e. those aged 0 to 14 years and over as a proportion of those aged 15 to 64 years) which is lower than the national rate of 49.3%; • The most diverse population nationally with 24.5% of its population being of ethnicity other than white Irish; • The lowest percentage nationally of those who report their health as being bad or very bad at 1.1% (national rate 1.5%) or who have a disability 10.2% (national rate at 13%); • The highest birth rate population nationally at 20.2 / 100,000 population and the second highest rate for breast feeding of 53.7% (national 46.6%); • The lowest suicide rate nationally; and • Cancer incidence rates above the national rate for male colorectal cancer and female malignant melanoma and male and female lung cancers.

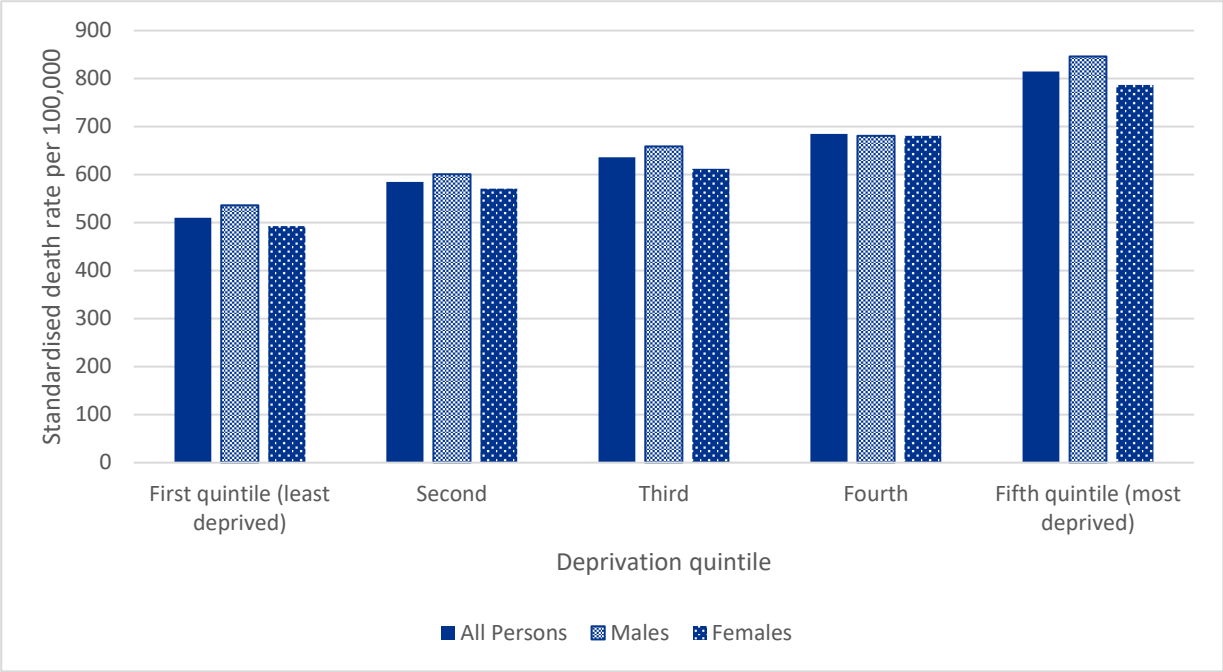
11.3.2 Deprivation, Disability and Health Inequalities

As briefly discussed in Section 11.1, wider determinants of health have a greater influence on a person's health outcomes over their life course than access to healthcare services, and there is a recognised social gradient of health. This can be seen for the population of Ireland as a whole between 2016 to 2017, where the death rate per 100,000 increased with every increasing deprivation quintile for both men and women (these data use the Standardised Death Rate (SDR) which is the death rate of a population adjusted to a standard age distribution to allow for comparisons between different areas where the age distribution may vary) (refer to Graph 11.4).

Analysis based on the Census characteristics of persons that died in the 12-month period after Census Day on 24 April 2016 shows the difference in life expectancy between different groups in society. The life expectancy at birth of males living in the most deprived areas of Ireland was five years less than the life expectancy at birth for males living in the most affluent areas (79.4 years compared with 84.4 years). Similarly, for women, the difference in life expectancy at birth was 4.5 years less for those living in the most deprived areas compared to those in the most affluent areas (83.2 years compared to 87.7 years) (CSO 2019a). The differential between male and female life expectancy was greatest in the most deprived areas with women living 3.8 years longer than men (CSO 2019a).

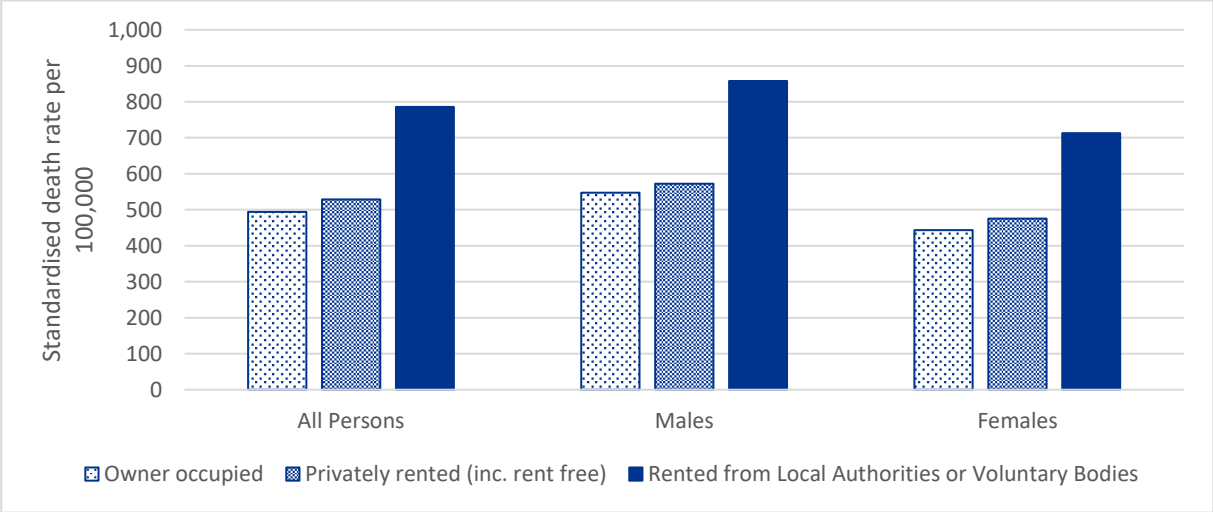
Disability also has a large influence on life expectancy at a population level. In Ireland, during the year 2016 to 2017, a 35 year old with a disability had a life expectancy of 13.7 years less than a 35 year old without a disability

(CSO 2019a). The SDR for those recorded as disabled in the 2016 Census was approximately four times the rate of those who did not indicate a disability (CSO 2019a).



Graph 11.4: Standardised Death Rate (SDR) per 100,000 by Deprivation Quintile in Ireland 2016 to 2017 (CSO 2019a)

A further factor associated with a higher mortality rate is whether a person owns or privately rents their home, or whether they rent from the local authority. Analysis of deaths in Ireland during the period 2016 to 2017 indicated that those who rent from a local authority have a mortality that is 1.6 times higher than those who are home owner-occupiers (refer to Graph 11.5). Level of education is also shown to have an association with life expectancy and health. According to the analysis of deaths during the year following the 2016 Census, those with only primary level education had almost twice the mortality rate as those with third level education.



Graph 11.5: SDR per 100,000 by Housing Sector Type in Ireland 2016 - 2017 (CSO 2019a)

The above issues (levels of deprivation, disability, levels of education and housing status) are heavily interlinked and there is likely to be a degree of confounding between the reported death rates associated with each issue (e.g. the death rate associated with education level may be skewed by the influence of deprivation, which is also associated with levels of education). However, the analysis undertaken by the CSO on mortality rate differences supports the concern over the influence of wider determinants of health on health outcomes, and the associated

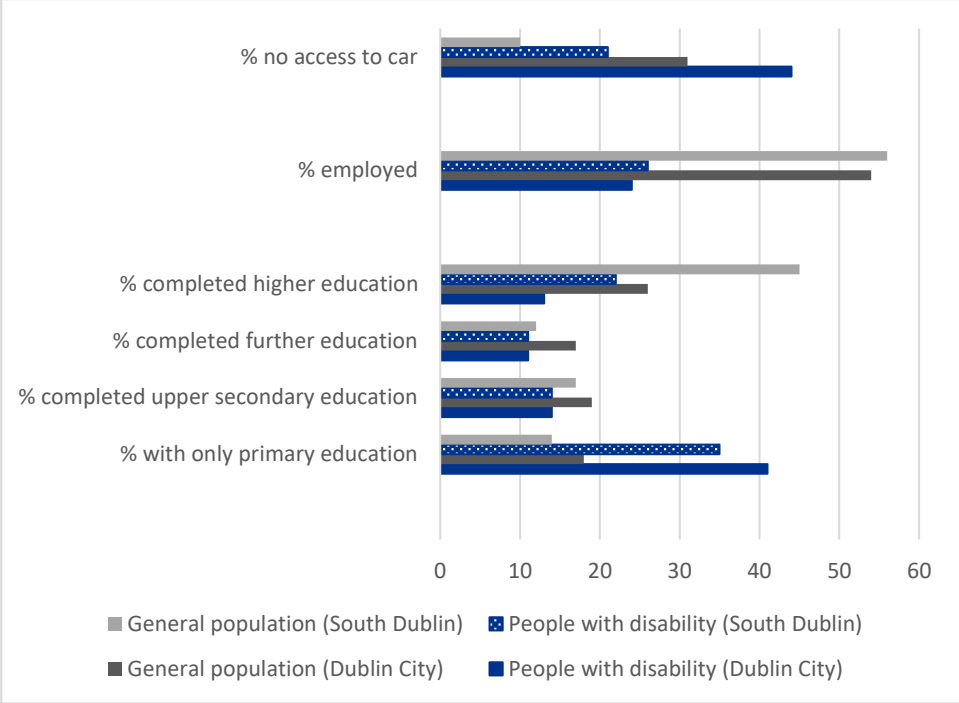
health inequalities that arise. The causes of these differences in health outcomes will relate to many different factors such as the prevalence of smoking, differences in dietary choices and alcohol consumption, levels of exercise, quality of social networks, housing conditions and other social and environmental conditions. Further research and analysis would be required to identify and quantify the factors responsible for the differences in mortality between affluent and deprived areas, which is beyond the scope of this assessment.

Within the study area, the key areas of disadvantage (refer to Figure 11.1 in Volume 3 of this EIAR) are in parts of Rowlagh, areas within Ballyfermot and Ballyfermot Upper parishes, and small pockets closer to the City Centre such as near St James's Hospital and James Street Parish. There is a likelihood that these communities carry a disproportionate burden of health problems compared to the average population. Although it should be noted that there will be sensitive individuals in all communities whose health may be disproportionately affected by changes in the environment and social conditions that may arise as a result of the Proposed Scheme.

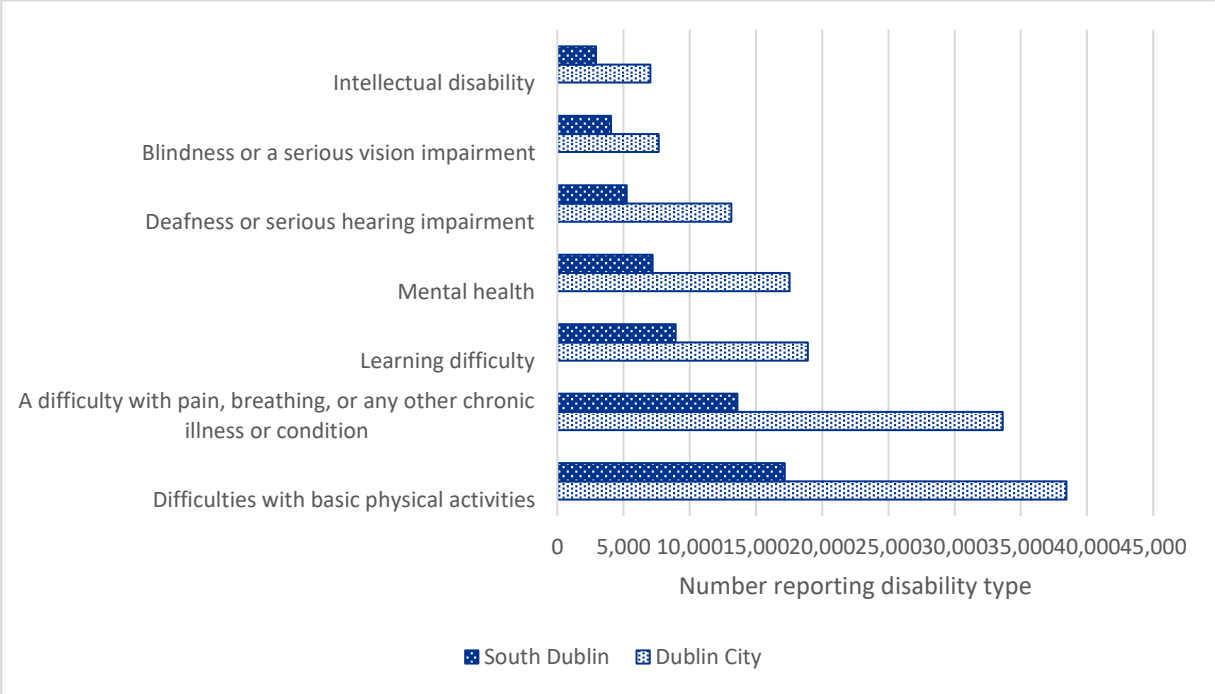
Table 11.5: Population, Disability and Relative Deprivation within Study Area (See Notes)

Indicator	Proposed Scheme Study Area
No. Small Areas in Study Area	193
Population in Study Area	52,767
Number and proportion with a disability	2,218 (4.2%)
% Small Areas in Deprivation/Affluence Category	
Extremely affluent	1.6%
Very affluent	6.7%
Affluent	29.5%
Marginally above average	28.5%
Marginally below average	14.0%
Disadvantaged	15.5%
Very disadvantaged	4.1%
Extremely disadvantaged	0%
% Local authority rented accommodation	12.5% (average across Study Area)
Notes: The population size has been derived by aggregating the populations of each Small Area which touches or coincides with the 500m buffer around the Proposed Scheme footprint. This will mean that some Small Areas extend beyond 500m and therefore provides only an approximation of the population within most influence of the Proposed Scheme. Deprivation and affluence data are mapped using Small Areas due to their relative uniformity in population size (mean household number is 100 households per Small Area). *Source of data: Pobal HP Deprivation Index 2016*	

The data in Table 11.5 shows that approximately 4.2% of people within the study area have at least one disability. This is a substantially lower proportion of the population than average for Dublin (14.9%) but nevertheless equates to 2,218 people. An analysis of 2016 Census data by Disability Federation Ireland (DFI) identified that 44% of people in Dublin City and 21% of people in South Dublin who have a disability do not have access to a car, compared to 31% of the general population. The analysis also shows lower educational attainment and lower rates of employment among people with disabilities compared to the general population (Graph 11.6).



Graph 11.6: Comparison of Education, Transport and Employment Data Between People with Disabilities and General Population in Dublin City and South Dublin (Data Source Census 2016 reported by DFI (DFI 2018))



Graph 11.7: Disability Types in Dublin City and South Dublin (Data Source Census 2016 reported by DFI (DFI 2018))

Graph 11.7 sets out the types of disability reported by people in Dublin City during the 2016 Census. This shows that the most common form of disability reported was difficulties with basic physical activities, followed by a difficulty with pain, breathing, or any other chronic illness or condition. While these are broad categories which cover several different conditions, it indicates the importance of accessibility and access to services as determinants of health. In 2005, the DFI prepared the Disability and Population Health Discussion Paper (DFI 2005). The Disability and Population Health Discussion Paper highlighted health inequalities associated with disability, including the importance of socio-economic status as a key determinant of health for people with disabilities, '*given the well established fact that poverty and disability are inextricably linked*'. The Disability and

Population Health Discussion Paper emphasised that people with disabilities are more likely to have lower levels of education and income and that they face extra costs in daily living associated with travel, heating, diet and medication. It also sets out that '*people with disabilities and their families are more likely than the rest of the population to live in poverty, and that this is a two-way relationship – disability adds to the risk of poverty, and conditions of poverty increase the risk of disability*' (Elwan 1999 in DFI 2005). The paper goes on to discuss the physical environment as a determinant of health for people with disabilities. It states that '*Physical access remains a major obstacle to the ability of people with physical and sensory disabilities to live in, and contribute, to their own communities. Lack of accessible public transport continues to be a major impediment to both the social and economic advancement, and subsequently the health of people with disabilities*'. The Disability and Population Health Discussion Paper also discusses the role of traffic accidents as a cause of disability (notably brain and spinal injuries), particularly in those under 25 years of age, since accidents and unintentional injuries were the most common cause of death and illness in that group (Kiely 2004 in DFI 2005). Road traffic accidents are covered in further detail in Section 11.3.4.

Some disabilities are not visible, such as autism spectrum disorder (ASD). It is estimated that approximately 1% to 1.5% of the population in Ireland has ASD (R&D and Health Analytics Division 2018). The autism spectrum covers a broad set of difficulties and people are affected in a variety of ways to differing degrees. The challenges that people with ASD face typically fall within the categories of communication and social skills, forming and keeping relationships with other people, physical coordination and sensory processing.

The Autism Spectrum Information Advice and Meeting Point (AsIAm) has published information on how people with ASD may struggle with using public transport, such as issues with lighting, noise, crowds, format of information, communication and reactions from other members of the public to how people with ASD behave and cope with anxiety and stressful situations (AsIAm 2015, Joint Committee on Transport, Tourism and Sport, 2018).

11.3.3 Air Quality, Noise and Other Pollutants

The links between air pollution and health effects are well established. The main pollutants from vehicle emissions are particulate matter (PM) and nitrogen oxides (NO_x). People are also exposed to ozone (O_3) which is produced by chemical reactions in the atmosphere. Both short-term and long-term exposure to air pollution is a significant cause of ill health and premature death. Air pollution causes short-term health effects on the respiratory system and more serious impacts due to long-term exposure including permanent reductions in lung function. Air pollution is linked to asthma, chronic bronchitis, cardiovascular disease, cancer, (Vardoulakis and Osborne 2017; Krzyzanowski 2005; Holgate *et al.*1999; Rajagopalan *et al.* 2018; Franklin 2015) and impaired foetal development (Lamichhane 2015). While exposure to air pollution can affect everyone, it can be particularly harmful for the elderly and the very young. For example, air pollution has been linked to decreased cognitive performance among the elderly, whilst exposure to air pollution for young children can have adverse effects such as hindering lung growth, inhibiting brain development and increasing the risk of conditions such as asthma (UN Environment 2018).

PM is particularly hazardous to human health as it is small enough to bypass the body's defence system and penetrate deep into the respiratory and circulatory system. Often PM contains harmful substances such as heavy metals, sulphurs, carbon compounds and carcinogens, which can have adverse health effects on the heart, lung and brain (WHO 2005, WHO 2021). $PM_{2.5}$ is the greatest environmental risk factor contributing to cardiovascular deaths and illness (Rajagopalan *et al.* 2018). There is emerging evidence that PM is also associated with lower birth weights (Pedersen 2013; Slama *et al.* 2007), premature births (Ritz *et al.* 2007; Rudra *et al.* 2011), and foetal growth restriction (Liu *et al.* 2007; Winckelmans *et al.* 2015).

Air quality standards are set to protect human health. It is notable that the WHO Air Quality Guidelines (WHO 2005) apply stricter guideline values for PM_{10} and $PM_{2.5}$ than the EU statutory limit values set out in Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on ambient air quality and cleaner air for Europe (hereafter referred to as the CAFE Directive). The WHO annual guideline levels have been reduced further in the recently published revised Air Quality Guidelines (WHO, 2021) following systematic review and synthesis by Chen and Hoek (2020) of more recent evidence of health outcomes associated with air pollution. The WHO's recommended annual air quality guideline (AQG) for $PM_{2.5}$ is set at 5µg/m^3 (micrograms per metre cubed) as opposed to the EU limit value of 25µg/m^3 (WHO 2005). This stricter value applied by WHO is considered preferable for health. It has been estimated that if $PM_{2.5}$ concentrations were reduced to 10µg/m^3 the number of premature deaths from all causes would be seven times lower than if $PM_{2.5}$ concentrations averaged 25µg/m^3

(Ballester *et al.* 2008). The WHO has provided four recommended interim targets of 35µg/m^3; 25µg/m^3; 15µg/m^3 and 10µg/m^3 (WHO, 2021).

In May 2020, as part of the joint WHO / United Nations Environment Program (UNEP) / World Bank *BreatheLife* campaign, the four Dublin local authorities signed a commitment to achieve the WHO Air Quality Guidelines standards by a target date of 2030.

Section 7.3 (Baseline Environment) of Chapter 7 (Air Quality) provides information on the baseline air quality relevant to the Proposed Scheme. The monitoring data indicate that annual average levels of particulates (PM_{10} and $PM_{2.5}$) in 2019 were within the EU limit values, although annual average concentrations for Finglas, , Phoenix Park, Rathmines and Marino for $PM_{2.5}$ at 9µg/m^3 , which exceed the WHO Air Quality Guidelines value of 5 µg/m^3 (WHO, 2021) and are marginally within the fourth interim target value of 10 µg/m^3. Site-specific monitoring of NO_2 in proximity to the Proposed Scheme, and roads that have the potential to be impacted by it, was carried out using passive diffusion tubes at seven sites (see section 7.3.2.2 in Chapter 7). The highest four-month average concentrations exceed the annual mean limit value and was recorded at a roadside location on the N4 which, was the most westerly monitoring location and 4.75m from the edge of the N4. Concentrations at this location were 46.1µg/m^3 or 115% of the annual mean limit value with the bias adjustment and annualisation factor applied. An exceedance of the annual mean limit was also recorded at the colocation with the EPA monitoring station at St. John's Road West which is opposite Heuston Station. The concentration at this location was 40.7µg/m^3 or 102% of the annual mean limit value for NO_2. The average concentration across all seven tubes was 31.6µg/m^3 or 79% of the annual mean limit value.

There is no 'safe' level of air pollution, and while concentrations may be below levels which are clinically significant on the health of individuals, low levels of air pollution can still have a measurable impact on health at a population level. Table 11.6 sets out the number of premature deaths attributable to various air pollutants for Ireland as a whole.

Table 11.6: Premature Deaths in Ireland Attributable to $PM_{2.5}$, NO_2 and O_3 Exposure in 2016 (European Environment Agency 2019)

Country	Population	$PM_{2.5}$		NO_2		O_3	
		Annual Mean (a)	Premature Deaths (b)	Annual Mean (a)	Premature Deaths (b)	SOMO35 (a)	Premature Deaths (b)
Ireland	4,726,000	6.8	1,100	11.2	50	1,323	30

Notes:
(a) The annual mean (in µg/m^3) and the SOMO35 (in µg/m^3·days), expressed as population-weighted concentration, is obtained according to the methodology described by ETC / ACM (2019) and references therein and not only from monitoring stations.
(b) The total deaths are rounded to the nearest hundred or ten.

Transport is the main source of noise pollution in Europe and, except for people living in close proximity to railway lines or airports, road traffic is the major cause of human exposure to environmental noise. Traffic noise causes impaired communication (difficulty in making oneself heard), sleep disturbance, annoyance and increased aggression. There is also increasing evidence of a link to heart disease and hypertension which could be significant given the large proportion of the population across Europe who are exposed to noise (Babisch 2006; van Kempen *et al.* 2002; Sobotova *et al.* 2009; Bluhm *et al.* 2007; WHO 2011). Research points to the strongest association with cardiovascular risk, being among those who are exposed to excessive noise (more than 65 dB(A) ('A-weighted' decibels) in the day or 55 dB(A) at night) in the long-term (i.e. living in the same house for 15 or more years) (Babisch 2006) and who live in older houses without triple glazing and who have bedrooms facing the street (Bluhm *et al.* 2007). It is therefore worth noting that the level of risk of more severe health outcomes such as cardiovascular events is very small for environmental noise compared to other risk factors. The most common associated health impacts are annoyance and sleep disturbance.

There has been concern about the potential impact of traffic noise on cognitive development in children. A systematic review of previous studies on this topic (Clark and Paunovic 2018) identified 13 studies of noise effects on cognitive impairment, from which four were cross-sectional studies of road traffic noise exposure, all of which were assessed through standardised assessments (SATs). Overall, the review indicated a variable level in the quality of the existing evidence, ranging from being of moderate quality for effects on outcomes such as reading comprehension or long-term memory, but being indicative of no substantial effect for other outcomes such as attention and executive function. The review also indicated the limited number of studies for some outcomes, and

in particular for some environmental noise exposures such as road traffic noise and railway noise. Nevertheless, the low number of studies and the quality of the evidence across them does not necessarily mean that there are no noise effects in some cognitive domains but rather, that more robust studies and a greater number of studies are required to support evidence-based assessments.

Taking into account the broad range of health outcomes associated with noise, WHO Europe has prepared Environmental Noise Guidelines for the European Region (WHO 2018). These guidelines include a strong recommendation that average daytime road traffic noise should be reduced to below 53dB L_{den} and that night-time traffic noise should be below 45dB L_{night}.

Section 9.3 (Baseline Environment) of Chapter 9 (Noise & Vibration) presents the existing ambient noise for locations relevant to the Proposed Scheme study area. As can be seen in Chapter 9 (Noise & Vibration) and its accompanying figures (Figure 9.1.1 and Figure 9.1.2 in Volume 3 of this EIAR) daytime noise levels are particularly high (exceeding 65dB(A)) for some properties close to the M50 Motorway at R833 Coldcut Road to Cherry Orchard Hospital, along R810 Old Kilmainham and R810 Thomas Street. Night-time noise levels exceed 55dB(A) in several locations, including Palmers Court, R833 Ballyfermot Road, R833 Sarsfield Road, R810 Old Kilmainham and R810 Thomas Street West. The night-time noise levels recorded along all sections of the Proposed Scheme route are currently above the WHO recommended level of 45dB (A) or less (please refer to Section 9.3 of Chapter 9 (Noise & Vibration) for further detail). Noise annoyance is subjective and the degree to which individuals would be sensitive to noise exposure will be variable. However, the noise levels indicated by the noise contour mapping show that many properties are already within areas where traffic noise levels are high enough to be associated with some of the adverse health responses identified in the Environmental Noise Guidelines for the European Region (WHO 2018). Residents of properties with direct frontage onto those roads recording high noise levels have the most potential of experiencing noise annoyance.

Between 1% and 10% of homes in Dublin City have radon levels above the national reference level for radon of 200 bequerel per cubic metre (Bq/m^3) (EPA 2020). Radon is a naturally occurring radioactive gas that is released by uranium, a natural substance found in soil and rock. It is captured in indoor air by moving through the ground to the air above. It is associated with damage to lung cells and risk of lung cancer (Lavin *et al.* 2006). Radon is the most significant cause of lung cancer after smoking and is estimated to cause between 3% to 14% of all lung cancers in a country, depending on the national average radon level and smoking prevalence (WHO 2016). There is a linear dose-response relationship between the risk of lung cancer and exposure to radon. The risk of lung cancer increases by 16% per 100Bq/m^3 increase in long-term average radon concentration (WHO 2016). Although smoking is by far a greater contributor to the risk of lung cancer (approximately 90% of all cases of lung cancer in Ireland are attributable to smoking (NCRI 2011; NCRI 2017)), there is evidence of a synergistic effect on risk of lung cancer from radon among those who smoke. Smokers are estimated to be 25 times more at risk from radon than non-smokers. To date, no other cancer risks have been established (WHO 2016). While the 2015 Health Profile for DCC (HSE 2015a) show incidences of lung cancer among men and women significantly above the average for Ireland as a whole, a study by Dempsey *et al.* only found statistically significant evidence of effect on risk of lung cancer from radon, where 10% to 20% of households were above the national reference level for the gas (Dempsey *et al.* 2017). Since exposure to radon is an indoor air pollution risk, there is no direct pathway between transport proposals and radon risk. However, there is a theoretical risk that large scale construction activities and changes to areas of hardstanding could lead to an indirect risk pathway, should it divert gas pathways into neighbouring properties. This risk is considered very low and is therefore scoped out of further consideration in the assessment.

11.3.4 Traffic, Travel Behaviour and Health

The health benefits of regular physical activity are well researched and widely accepted. For most people, the easiest forms of physical activity are those that can be built into daily life, for example, by using walking or cycling as an alternative to motorised transport for everyday journeys such as commuting to work or school. Active forms of travel, such as walking and cycling, are associated with a range of health benefits. These include improved mental health, reduced risk of premature death and prevention of chronic diseases such as coronary heart disease, stroke, type 2 diabetes, osteoporosis, depression, dementia and cancer (British Medical Association 2012). Research also suggests that countries with the highest levels of active travel generally have amongst the lowest obesity rates (Bassett *et al.* 2008).

There has been growing concern over increasing levels of obesity in Ireland, with the percentage of people in Ireland who are overweight or obese has risen from 31% in 1998 (Kavanagh *et al.* 2005) to 62% in 2017 (CSO 2019b). Physical inactivity is a key risk factor for obesity and switching from active modes of travel (walking and cycling) to car use has helped to fuel physical inactivity. Car ownership has increased in Ireland, with just under 60% of urban households owning a car in 1986 compared with just under 80% of households owning a car in 2016 (CSO 2019c). Since 2011, there has been a very slight decline in car ownership among urban households and car ownership in cities in 2016 was substantially lower than rural areas (76.6% compared to 91%) (CSO 2019c).

Section 10.3 (Baseline Environment) in Chapter 10 (Population) identifies the method of travel to work for bus, train, car and foot / bike for the population in the 10 community areas that make up the study area for that topic. 17% of residents in Ballyfermot parish cycled or walked to work, which is in line with the average proportion for Dublin as a whole, and 13% of residents in Ballyfermot Upper, 6% in Lucan, 10% in Palmerstown and 15% in Rowlagh - Quarryvale cycled or walked to work, which is below the average proportion for Dublin as a whole. The proportion of residents who cycled or walked to work in the remaining communities (all closer to the City Centre) was substantially higher than average for Dublin as a whole. The dataset shows that the parishes of Lucan, Palmerstown and Ballyfermot Upper each had a higher proportion of residents commuting to work by car or van than average for County Dublin. These parishes are the furthest from the City Centre but they are however within a distance of 6km to 12km, distances over which can typically be undertaken by bicycle within approximately 26 to 51 minutes based on an average cycling speed of 14kph (CSO 2019d). Given that approximately 45% of work commutes in South Dublin and approximately 45% in DCC took 30 minutes or less there is potential to encourage modal shift from car use to cycling if the right conditions are provided and this would likely bring health benefits (CSO 2019c). Section 6.3 (Baseline Environment) of Chapter 6 (Traffic & Transport) describes the quality of pedestrian and cycle infrastructure provision in the study area. It identifies that for much of the Proposed Scheme, the quality of cycle provision ranges from B to C against the Quality of Service guidelines in the NTA's National Cycle Manual, indicating that quality could be improved (NTA 2011).

The data in Section 10.3 (Baseline Environment) in Chapter 10 (Population) also shows that travel by bus increases above the Dublin average with distance from the City Centre, with Ballyfermot and Chapelizod having the greatest proportions of residents who travel by this mode. A study into the influence of public transport use on exercise levels suggests that those who walk to and from public transport stops achieve a notable amount of daily travel-related physical activity (median of 19 minutes) and that 29% of public transport walkers get 30 minutes of daily physical activity solely by walking to and from transport stops (Besser 2007).

Dublin is the sixth most congested city in Western Europe (TomTom 2019). High traffic volumes and speeds can reduce opportunities for positive contacts with other residents in a neighbourhood, contributing towards increased social isolation and reduced community cohesion (Appleyard 1981; Hart and Parkhurst 2011). Individuals who are socially isolated are more likely to make use of public services due to lack of support networks and have an increased likelihood of developing certain health conditions such as depression and dementia (Social Finance 2015). They are also more likely to be physically inactive (Appleyard 1981), which is again linked to increased likelihood of developing certain diseases as discussed above. People experiencing high levels of social isolation have significantly higher mortality levels than those with low or average levels of isolation (Steptoe *et al.* 2013).

The SDR from transport accidents has declined in Ireland from 7.6 per 100,000 in 2006 to 3.7 in 2014 (CSO 2019a). An Garda Síochána provides traffic collision data that involves an injury to the Road Safety Authority (RSA). The RSA collision data for the period 2005 to 2016 indicates locations for 17 traffic accidents along the route of the Proposed Scheme that resulted in serious injury or a fatality. Of these, seven (41%) involved pedestrians, while one (6%) involved a cyclist. Risk of death from traffic accidents in Ireland is not evenly distributed across the population and has been shown to be higher among deprived communities, males and persons in late adolescence / early adulthood (Kavanagh *et al.* 2005). In addition to deaths and physical injuries, wider effects on society are also an issue. A follow up study of 1,148 people aged 19 to 69 years who attended Accident and Emergency (A&E) following a road accident identified that 32% suffered notable psychiatric outcomes (post-traumatic stress disorder, phobic travel anxiety, general anxiety or depression) at one year following the accident (Mayou R. 2001; Kavanagh *et al.* 2005).

There is concern that the promotion of active travel modes would lead to greater increases in casualties among pedestrians and cyclists. However, evidence suggests that there is 'safety in numbers' for walkers and cyclists. One key study into this concept was reported by Jacobsen (Jacobsen 2003). Jacobson provided evidence based

on analysis of national data from 14 European countries on walking and cycling, as well as data for 47 towns in Denmark, and 68 towns in California. The author concluded that:

- '*there is a relationship between motor vehicle collisions with pedestrians and or cyclists and numbers of pedestrians and or cyclists. For example, in a community where walking doubles it can be expected that there will be a 32% increase in pedestrian injuries, where cycling doubles it can be expected that there will be a 34% increase in cyclist injuries*';
- '*motorists appear to adjust their behaviour in the presence of people walking and cycling which largely controls the likelihood of collisions; as a result*'; and
- '*the relationship between pedestrians or cyclists' exposure and casualties is not linear, that is, there is safety in numbers for these mode users*'.

A number of other studies have provided further evidence to support the safety in numbers principle (Robinson 2005; Bonham *et al.* 2007; Pucher and Dijkstra 2003).

11.3.5 Access to Healthcare, Employment and Education

Transport is required for access to a variety of resources important to health and social inclusion, including traveling to work or school, visiting family and friends, accessing health services, and shopping and leisure. Poor access to transport results in barriers to these important health resources and can contribute to health inequalities and social exclusion. Key issues for transport are affordability; availability; and accessibility

Section 10.3 (Baseline Environment) in Chapter 10 (Population) presents baseline accessibility in relation to access to work, healthcare and other community facilities.

The following notable healthcare facilities have been identified in the Human Health study area:

- St. Bricin's Military Hospital, Infirmary Rd, Stoneybatter, Dublin 7 (approximately 370m north of the Proposed Scheme route)
- St. Patrick's University Hospital, St James's Street, Dublin 8 (approximately 70m south of the Proposed Scheme route)
- St. James's Hospital, R810 James Street, Dublin 8 (approximately 370m south of the Proposed Scheme route)
- St Mary's Hospital Nursing Home, Phoenix Park, Chapelizod, Dublin 20 (approximately 440m north of the Proposed Scheme route)
- Stewarts Hospital, Mill Lane, Palmerstown, Dublin 20 (abuts the Proposed Scheme route corridor)
- Hermitage Medical Clinic, Lucan Rd Old, Fonthill, Dublin 20 (abuts the Proposed Scheme route corridor)
- St. Loman's Hospital, Mount Andrew Rise, Yellow Walls, Lucan 20 (abuts the Proposed Scheme route corridor)
- Ballydowd Special Care Unit (a high-security centre for children aged between 12 and 17 with serious emotional and behavioural difficulties) Liffey Crescent, Liffey Valley Park, Lucan, Dublin 20 (approximately 25m of Proposed Scheme route corridor)

The main hospitals in the study area have limited parking facilities however are served by public transport services such as Dublin Bus, the LUAS and Dublin Bikes.

There are also several schools in the Human Health study area, notably, Saint John of God's Special School at Kilmainham, Saint Dominic's Secondary School in Ballyfermot and The King's Hospital School, Palmerstown all abut the Proposed Scheme corridor. In addition, the above-mentioned Ballydowd Special Care Unit also provides education services to its resident children.

The locations of health and education facilities are presented on Figure 11.1 in Volume 3 of this EIAR. The impact of the Proposed Scheme on baseline access to services will be an important consideration in terms of links to health and wellbeing.

11.3.6 Communicable Diseases

While the dominant causes of ill health and premature death in Ireland are non-communicable diseases, typically associated with lifestyle factors such as diet, alcohol consumption and physical activity levels, the COVID-19 pandemic that has affected Ireland in 2020 and 2021 has brought the risk of communicable diseases into sharp focus.

COVID-19 is a viral illness caused by the coronavirus SARS Co-V 2. It was first described in China in late 2019 and has gone on to cause a global pandemic. In Ireland, it led to a number of 'Level 5' restrictions with closures of hospitality, entertainment and non-essential work. It has also led to restrictions on the numbers who could use public transport at any time. Nevertheless, at all times during the pandemic, public transport has continued to operate. This is because it is an essential service, transporting essential workers to and from their workplaces.

Early in the pandemic it was feared that public transport could be a major vector of transmission of COVID-19. However, evidence has suggested otherwise. A useful review of evidence was published by the International Association of Public Transport (UITP 2020). The review considered studies from Germany, France, the UK and Japan. The studies showed very low levels of COVID-19 cases traceable to public transport. The UITP concluded that public transport is safe in an era of COVID-19, providing that precautions such as the use of face masks and sanitiser are employed.

COVID-19 is often transmitted from an infected person through droplets generated when they talk, cough, sneeze or exhale. Some of these convert into aerosol particles, which are lighter than droplets and can be spread further and remain in the air for longer, and anyone who inhales them can become infected. Several studies have concluded that the transmission of droplets and aerosols can be prevented, or at least limited, by using a face covering, even in more confined spaces such as public transport. The importance of face coverings in reducing transmission of COVID-19 became increasingly evident as the pandemic progressed.

The WHO has suggested that air pollution is most likely a contributing factor to the health burden caused by COVID-19, as polluted air is already known to inflame the lungs and cause respiratory and heart disease that make people more vulnerable (WHO 2020 in UITP 2020). The use of public transport, walking and cycling may therefore help to reduce the health burden of respiratory diseases such as COVID-19 by associated reductions in air pollution.

The vaccination programme has been effectively rolled out in Ireland. There are a number of vaccines which appear highly effective, although there is the risk of the emergence of new coronavirus variants which could be resistant to existing vaccines. However, it is likely that further vaccines would be developed to address this development.

While the COVID-19 situation appears increasingly hopeful, the experience has demonstrated the reality of the risk of other infections and pandemics in the future. The recent experience has shown that public transport will continue to be required even in the events of such pandemics.

11.3.7 Summary of Key Baseline Health Issues

Overall, Dublin has a better health profile than average for Ireland with lower mortality rates. The leading causes of death relate to non-communicable health conditions (heart disease and stroke; cancer; respiratory disease, and injury and poisoning). Dublin has higher cancer rates than the national average.

Based on available monitoring data, levels of air pollution are almost entirely within the EU limit values for NO_2 and PM. However, there is a relatively high prevalence of exposure to excessive traffic noise, particularly at night-time for properties close to the Proposed Scheme corridor.

Exposure to traffic noise causes annoyance and is linked to several other adverse health outcomes. There is widespread exposure in the study area to noise levels which exceed the levels set out in the Environmental Noise Guidelines for the European Region (WHO 2018) which are recommended to prevent adverse health outcomes.

Rates of walking and cycling are relatively high for communities in the study area within 4km of the City Centre, but car dependency increases beyond 5km. Switching from sedentary modes of travel (i.e. car use) to more active modes (walking and cycling) reduces risk of a number of causes of premature death.

Evidence from many different countries and contexts, including Ireland as a whole, shows that there is a social gradient of health whereby people in deprived areas suffer worse health outcomes than those in affluent areas. Assuming this holds true for Dublin, the areas with higher levels of deprivation in the study area are likely to carry a greater burden of disease and may be disproportionately affected (either adversely or beneficially) by impacts from the Proposed Scheme.

11.4 Potential Impacts

This section presents the potential impacts that may occur due to the Proposed Scheme, in the absence of mitigation. This informs the need for mitigation or monitoring to be proposed (refer to Section 11.5). Predicted 'residual' impacts taking into account any proposed mitigation is presented in Section 11.6.

11.4.1 Characteristics of the Proposed Scheme

The Proposed Scheme is described in detail in Chapter 4 (Proposed Scheme Description) of this EIAR. In summary the Proposed Scheme will be approximately 9.6km in length. The purpose of the Proposed Scheme is to enhance public transport and cycling accessibility between Lucan and the City Centre.

The Proposed Scheme will commence at Junction 3 on the N4. It is routed via the N4 as far as Junction 7 (M50), and via the R148 along the Palmerstown Bypass, Chapelizod Bypass, Con Colbert Road and St John's Road West as far as Frank Sherwin Bridge, where it will join the prevailing traffic management regime on the South Quays.

Chapter 5 (Construction) of this EIAR describes the construction of the Proposed Scheme. Reference should be made to Chapter 5 (Construction) for a description of the construction activities and programme of works for each section. The key characteristics and impacts of the Proposed Scheme of relevance to human health during the Construction Phase are:

- Traffic management required, such as temporary traffic diversions or lane restrictions, to allow completion of particular elements of the Proposed Scheme whilst maintaining traffic flows as far as reasonably practicable (refer to Chapter 5 (Construction));
- Noise and vibration during the Construction Phase from construction activities, construction plant and construction vehicles (refer to Chapter 9 (Noise & Vibration));
- Dust and potential air pollution from construction activities and plant (refer to Chapter 7 (Air Quality));
- General disruption of footways, cycleways and other areas, such as closed off areas and temporary diversions, and temporary surfacing, due to construction works (refer to Chapter 5 (Construction)); and
- Occasional interruption of services such as water and power to allow some elements of construction activities to take place (refer to Chapter 19 (Material Assets)).

The key characteristics and impacts of the Proposed Scheme of relevance to human health during operation are:

- Bus priority, so that buses are not delayed by general traffic congestion, improving journey times and journey reliability for bus users;
- Redistribution of general traffic away from the Core Bus Corridor as a result of reduced reserve capacity along Proposed Scheme, will alter traffic flows and speeds on other streets in and around the Proposed Scheme which could affect levels of emissions of air pollution, noise and pedestrian and cyclist accessibility (refer to Chapters Chapter 6 (Traffic & Transport), Chapter 7 (Air Quality) and Chapter 9 (Noise & Vibration);
- Enhanced pedestrian and cyclist crossing facilities at certain locations;
- Proposed new cycleways which will create an improved facility for cyclists;
- Urban realm improvements through hard landscaping and soft landscaping choices to provide visual improvement; and

- Small areas of land acquisition to accommodate elements of the Proposed Scheme will be required such as from the Hermitage Golf Club, Palmerstown Lodge Hotel, Hermitage Medical Clinic, Applegreen service station and the City of Dublin Education and Training Centre (See Chapter 10, Population) to accommodate the dedicated cycle tracks and footways.

11.4.2 'Do Nothing' Scenario

In the Do Nothing scenario, the Proposed Scheme would not be implemented and there would be no changes to existing highway infrastructure, so infrastructure provision for buses, pedestrians and cyclists would remain the same. The streetscape would continue to be based around the movement and parking requirements of private cars. High levels of traffic are associated with discouraging pedestrian and cyclist activity, and so the pattern of increasingly sedentary lifestyles, and the associated adverse health effects associated with this (see Section 11.3.4) would continue, and potentially worsen as traffic congestion is predicted to increase. The baseline situation of high levels of traffic congestion and consequent delays to public transport would also continue, and potentially become exacerbated over time as traffic congestion is predicted to increase.

The current trends in the health baseline are likely to continue in the 'Do Nothing' scenario, although there is still considerable uncertainty at the time of assessment as to the impact of the COVID-19 coronavirus pandemic on travel behaviour, healthcare services, the economy and people's lifestyles, all of which would have direct and indirect effects on population health. It should be noted that travel demand and patterns of travel are anticipated to grow in line with population growth.

11.4.3 Construction Phase

The implications of temporary traffic management on issues relating to human health have been assessed. Specifically, the assessment considers the potential impacts on access to health services and health impacts associated with traffic congestion and diversions. Chapter 10 (Population) provides a general assessment of accessibility, considering a wider range of community services and facilities, as well as impacts from land acquisition. None of the impacts identified in the Population assessment are considered likely to be significant in terms of population health. For example, while a small degree of land-take is anticipated from the boundary of the Hermitage Medical Clinic site, this will not impact on any medical functions of the clinic and therefore no likely significant impacts on health are anticipated. Chapter 19 (Material Assets) provides an assessment of impacts on utilities such as water supply and power. It is not considered that any interruption of these services would be of a scale that could have any likely significant effects on human health, and therefore this issue is scoped out of the assessment.

11.4.3.1 Temporary Impacts on Access to Health Services

It is not anticipated that the slight loss of land from the Hermitage Medical Clinic to accommodate a retaining wall and realignment of footway and cycleway (See Chapter 4, Proposed Scheme Description) will have any impact on the function of the medical facility and therefore this aspect (land acquisition) of the Proposed Scheme will not have any impact on access to health services.

There are several health services located within the immediate vicinity of the Proposed Scheme (see section 11.3.5 of this Chapter) which may experience temporary impacts as a result of construction works. It is anticipated there will be approximately twelve months of construction work between N4 Eastbound Carriageway, Junction 3 Lucan to Junction 2 Liffey Valley (section 1d of the Proposed Scheme, see Chapter 5 (Construction) in this EIAR). The Hermitage Medical Clinic is accessed off Junction 2 and also via Old Lucan Road west of the M50. St. Loman's Hospital and Ballydowd Special Care Unit are located off the west-bound carriageway of N4, opposite the Hermitage Medical Clinic. It is not anticipated there will be any notable impact on access to these facilities throughout the Construction Phase. Works along Old Lucan Road in the vicinity of Stewarts Hospital are not anticipated to last for more than around three months and are not likely to affect any access to the hospital.

There may be periods of traffic congestion along some sections of the Proposed Scheme and on the wider road network from redistributed traffic, which could delay access to other healthcare facilities, but this is in the context of regular traffic congestion in Dublin (see Section 11.3.4). Access will be maintained to all hospitals and healthcare facilities. In terms of access for non-emergency appointments, since access will be maintained to hospitals, it is likely that additional time for journeys can be planned for in advance. The risk of missing appointments to health services for the general population is low, and health outcomes associated with these

impacts are more likely to be frustration, annoyance and temporary stress as a consequence of inconvenience. For the majority of patients, the impact from this is expected to be Negative, Slight and Short-term at most. Individuals likely to be more sensitive to these impacts would include those who suffer from anxiety, depression and other mental health conditions. Since there are specialist mental healthcare services at St. Loman's Hospital and St. Patrick's University Hospital, there will be a relatively high proportion of the affected population which will be sensitive to disruption. The secure, residential nature of the Ballydowd Special Care Unit means it is unlikely that its residents would be particularly sensitive to traffic disruption as the patients would be living on-site. However, there is a risk for some staff. Therefore, the potential impact of the Construction Phase on access to these mental healthcare facilities is assessed as Negative, Moderate and Short-term.

The Hermitage Medical Clinic is a private hospital which has an emergency department. Survival rates from out-of-hospital cardiac arrests (Lyon et al. 2004) and stroke (Simonsen et al. 2014) are strongly influenced by emergency response times. Therefore, any delay to emergency admissions caused by traffic disruption could have a significant impact on health outcomes for some individuals who need emergency care. Access will be maintained along the Proposed Scheme for emergency vehicles at all times, throughout the Construction Phase. Any traffic disruption elsewhere along the Proposed Scheme route is likely this will be in line with baseline trends of traffic congestion. On this basis the effect on access to emergency healthcare is assessed as Negative, Moderate and Short-term.

11.4.3.2 Health Impacts from Temporary Traffic Diversions

Temporary diversions of pedestrians and cyclists may increase the likelihood of collisions with traffic if not appropriately managed. The traffic management arrangements, as described in Chapter 5 (Construction), will set out alternative routes and crossing arrangements for pedestrians. Where feasible, temporary cyclist provision will be made to assist cyclists where cycle paths or cycle lanes are temporarily closed for construction activities. In some instances, cyclists may be required to share space with vehicular traffic which could expose cyclists to risk of collisions with vehicles, particularly if there is route uncertainty or lanes are narrow. However, there is a requirement to adhere to the Traffic Signs Manual, Chapter 8 Temporary Traffic Measures and Signs for Roadworks (Department of Transport Tourism and Sport 2019) which provides guidance for the protection of vulnerable road users, including cyclists, when undertaking roadworks. This includes ensuring there is sufficient space for cyclists in the event it is necessary for cyclists to share space with vehicular traffic. The required provision for cyclists will be determined by the street characteristics and the guidance notes that '*the overall risk to cyclists should be considered on a case-by-case basis*'. The provision will be determined as the detailed Construction Traffic Management Plan (CTMP) is subsequently prepared by the appointed contractor prior to construction, including Temporary Traffic Management arrangements prepared in accordance with the Traffic Signs Manual, Chapter 8 Temporary Traffic Measures and Signs for Roadworks (Department of Transport Tourism and Sport 2019). However, it is assumed that the provision will ensure risk to both cyclists and pedestrians is mitigated. On this basis, the potential impact to human health from traffic collision related injuries will be Negative, Moderate and Temporary to Short-Term, as it is expected that exposure to risk during construction would be in line with current trends in the street environment.

11.4.3.3 Health Impacts from Temporary Traffic Congestion

Traffic management will be required to allow space for working areas during construction. This will reduce capacity and, as described in Chapter 5 (Construction), some temporary traffic disruption is expected. Traffic congestion may also arise as a consequence of loading and unloading of construction vehicles bringing materials and plant to and from the work areas. Proposals for traffic management during the Construction Phase are set out in Section 5.8 of Chapter 5 (Construction)

Psychological stress is associated with traffic congestion (see Section 11.3.4) which is typically self-reported and does not have a precise medical definition. It is not anticipated there will be a notable change in traffic congestion for the majority of the route, with disruption limited to short sections of stop-go systems and temporary/weekend night-time closures. The Chapelizod Hill Road will, however, need to be closed for a period of two to three months to facilitate construction, but a diversion route will be provided via Lucan Road / Kylemore Road and pedestrians can be accommodated generally, but it is envisaged that there will be impacts at some stage: craning in structures, moving the piling rig from one side of Chapelizod Hill Road to the other, etc. it is estimated that the duration of these impacts will be in the order of two to five days.

Given that traffic congestion is a key existing issue for Dublin (see Section 11.3.4) it is unlikely that congestion associated with the construction of the Proposed Scheme would contrast notably from the baseline situation, as

routine highway maintenance, loading/unloading activities and traffic incidents would regularly contribute to temporary increases in congestion with associated effects on driver stress. On this basis, the potential impact will be Negative, Slight and Short-Term for the general commuting population who use the route and will be Negative, Moderate and Short-Term for more sensitive groups.

11.4.3.4 Construction Related Air Pollution and Health

Chapter 7 (Air Quality) reports that when comparing the 2024 Do Something Scenario with Do Minimum Scenario for NO_2 impacts at most impacted receptors, a slightly beneficial impact is estimated at 30 receptors, a moderate beneficial impact at five receptors and a substantial beneficial impact is expected at two receptors. All beneficial impacts are modelled along the Proposed Scheme. A slight adverse impact is expected at two receptors. For both PM_{10} and $PM_{2.5}$ the impact of construction is assessed as neutral as there are negligible differences in concentrations of these particulates between the Do Something and Do Nothing scenarios for 2024. From a human health perspective, it is not considered these impacts would have a noticeable impact on health status, although it is likely that more people would be exposed to improved air quality than worsened air quality (relating to NO_2). It is therefore assessed as Positive, Not Significant, Short-term.

Construction activities may generate nuisance dust. Chapter 7 (Air Quality) has assessed the risk of dust impacts as low risk and has predicted that the impact of dust in terms of air quality will be neutral and short-term with dust management measurements in place. The potential for local residents to become anxious about the potential impacts of dust, and possibly attribute any respiratory symptoms they may have to perceived impacts from construction dust cannot be discounted. It is not considered that there will be a lasting impact, and the impact will be managed by means of an effective Construction Environmental Management Plan (CEMP) (refer to Appendix A5.1 CEMP in Volume 4 of this EIAR) incorporating the mitigation measures outlined in Section 7.5 (Mitigation and Monitoring Measures) in Chapter 7 (Air Quality). The potential health impacts from construction dust will be Negative, Slight and Temporary.

Earthworks, demolition and construction activities can be associated with the release of fungal spores into the atmosphere. Aspergillus is a ubiquitous organism and is present everywhere but is of particular concern when large scale demolition, excavation and earth-moving activity takes place. The vast majority of people are immune to this, but invasive aspergillosis is a disease which is harmful to people with suppressed immune systems such as hospital inpatients. Fungal spores are dispersed to no measurable concentration at approximately 250m from the source of the release. This issue is therefore considered in this assessment due to the presence of the Hermitage Medical Clinic, St. Patrick's University Hospital, St. Loman's Hospital and Stewarts Hospital in the study area within this distance (see Section 11.4.3.1). The National Guidelines for the prevention of Nosocomial Aspergillosis During Construction/ Renovation Activities (Health Protection Surveillance Centre 2018) deals specifically with construction works occurring within or adjacent to hospitals. The National Guidelines note that the fundamental requirements in preventing Aspergillus infection arising from construction works are, first, to minimise the dust generated during construction and, second, to prevent dust infiltration into patient care areas. Works in the vicinity of the hospitals will be carried out in accordance with the National Guidelines with dust suppression measures in place. Furthermore, susceptible patients are normally placed in specially designed units that have highly filtered air to protect them from outside sources. On this basis it is assessed that the risk of invasive aspergillosis is Negative, Not Significant and Short-Term.

11.4.3.5 Construction Noise and Vibration and Health

Chapter 9 (Noise & Vibration) reports that with mitigation in place, during the Construction Phase of the Proposed Scheme, noise levels at properties closest to working areas will be temporarily increased. The construction working hours will be time restricted and subject to Local Authority requirements and agreements. Normal construction working hours will be restricted to between 07:00hr and 23:00hrs on weekdays, and between 08:00hrs and 16.30hrs on Saturdays. Night-time and Sunday working may be required in order to minimise the impact on road traffic movements during the daytime, for example at busy road junctions and in commercial areas and for such works as pavement/road surfacing. Any such working hours outside the normal construction working hours will be agreed with DCC / SDCC. The planning of such works will take consideration of sensitive receptors, in particular any nearby residential areas. The most appropriate noise mitigation measures for each works area will be determined taking account of the various control measures included within Section 9.5 (Mitigation and Monitoring Measures) of Chapter 9 (Noise & Vibration), and Appendix A5.1 Construction Environmental Management Plan (CEMP) in Volume 4 of this EIAR.

The greatest noise impacts are predicted for noise sensitive receptors within 10m of road widening / utility diversion works when evening activities take place as the 65 dB $L_{Aeq,4hr}$ as the Construction Noise Threshold could be exceeded by more than 5dB. This could impact on residents within Noise Sensitive Locations (NSL) identified in Table 9.28 (Chapter 9 (Noise & Vibration). However, mitigation would be included to limit the durations of activities as set out in Section 9.6.1 of Chapter 9 (Noise & Vibration), which will reduce the significance.

The construction noise impacts may in some places be above the guidelines associated with health effects. In terms of effects on health, there is potential for occasional sleep disturbance at night for residents who live within approximately 15m of the Proposed Scheme, and during the day for shift workers. Other health outcomes are likely to be annoyance and temporary psychological stress as a reaction to noise. There is no evidence for significant effects on health outcomes from transient levels of annoyance or occasional sleep disturbance.
People likely to be more sensitive to these impacts could include those with ASD (autism spectrum disorder) and those who suffer from anxiety. The predicted noise impacts will be temporary, and therefore unlikely to be attributable to a change in health status for the general resident population, although sensitive individuals are likely to experience a degree of annoyance, which may result in some complaints. On this basis, the potential impact of noise and vibration on population health will be Negative, Moderate and Temporary on the neighbouring population.

11.4.3.6 Other Environmental Hazards

Chapter 13 (Water) and Chapter 14 (Land, Soils, Geology & Hydrogeology) have not reported any residual impacts of a nature that could be linked to likely significant effects on human health outcomes. On this basis, the potential impact of other environmental hazards associated with the Construction Phase of the Proposed Scheme on population health will be Neutral.

11.4.3.7 Summary of Potential Construction Phase Impacts

Table 11.7 provides a summary of the assessment of impacts described in Section 11.4.3.1 to Section 11.4.3.6. No significant impacts on human health are predicted during construction.

Table 11.7: Summary of Potential Construction Phase Impacts

Assessment Topic	Associated Health Outcomes	Potential Impact
Temporary Impacts on Access to Health Services	• Emergency healthcare outcomes (Hermitage Medical Clinic Emergency Department)	Negative, Moderate and Short-term. Access to emergency healthcare will be maintained throughout construction and impacts of traffic disruption on response times are expected to be typical of baseline trends of traffic congestion in Dublin.
	• Mental health and wellbeing (including patients at St. Loman's Hospital, Ballydowd Special Care Unit and St. Patrick's University Hospital).	Negative, Moderate and Short-term. Traffic disruption from Proposed Scheme may be more keenly felt by vulnerable mental health patients, but access to healthcare will be maintained and effects would be temporary and reversible.
	• General health outcomes associated with access to healthcare • Temporary psychosocial effects such as frustration, annoyance and stress	Negative, Slight and Short-term. Access to healthcare is likely to be maintained albeit with some minor inconveniences of access. Effects would be temporary and reversible.
Health Impacts from Temporary Traffic Diversions	• Risk of injury from road collisions, especially for pedestrians and cyclists	Negative, Moderate and Short-term on the basis that there is limited cycling provision in the baseline that would be affected and that measures will be implemented to protect diverted cyclists and pedestrians.
Health Impacts from Temporary Traffic Congestion	• Temporary psychosocial effects such as frustration, annoyance and stress	Negative, Slight and Short-term for the general commuting population.
		Negative, Moderate and Short-term for more sensitive people (e.g. those who suffer from mental health conditions such as anxiety).

Assessment Topic	Associated Health Outcomes	Potential Impact
Construction Related Air Pollution – Construction Traffic and Plant Emissions	• Exacerbation of asthma and other respiratory conditions	Negative, Slight and Short-term – the degree of exposure to predicted changes in NO_2 is expected to present a very low risk to population health.
Construction Related Air Pollution - Dust	• Exacerbation of asthma and other respiratory conditions • Temporary psychosocial effects such as frustration, annoyance and stress	Negative, Slight and Temporary on the basis that there would be potential concern about risk from construction emissions which individuals may associate with their symptoms.
	• Risk of invasive aspergillosis	Negative, Not Significant, Short-term risk for patients in Hermitage Medical Clinic, St. Patrick's University Hospital, St. Loman's Hospital and Stewarts Hospital, on account of dust control measures in place.
Construction Related Noise	• Temporary psychosocial effects such as frustration, annoyance and stress • Sleep disturbance (shift workers)	Negative, Moderate and Temporary on the basis that no change in health status is anticipated from the temporary and occasional construction noise impacts.
Other environmental hazards (water pollution, flood risk, ground contamination)	• Various health outcomes	Neutral. No residual impacts from other environmental factors have been identified as likely to affect health.

11.4.4 Operational Phase

11.4.4.1 Health Impacts of Increased Physical Activity

The Proposed Scheme will introduce improved pedestrian and cycling facilities, as well as improved reliability of journey times for buses. There is a substantial body of good evidence to demonstrate that investment in walking and cycling infrastructure can increase rates of physical activity among children and adults (Carlin *et al.* 2015; D'hease *et al.* 2015; Grasser *et al.* 2013; Wanner *et al.* 2012.). There is moderate to good evidence that such infrastructure can lead to health gains, for example the implementation of new cycle lanes has been associated with improved cardiovascular health and improved weight management (D'hease *et al.* 2015; Mueller *et al.* 2015, Wanner *et al.* 2012.). Furthermore, studies also suggest that those who walk to and from public transport stops obtain a notable amount of daily transport related physical activity, with one study showing that 29% of public transport walkers achieved 30 minutes of daily physical activity purely by walking to and from transport stops (Besser and Dannenberg 2005). The Cambridgeshire Guided Bus Project in the UK provides evidence that physical activity is likely to increase from new bus and cycle infrastructure. One study (Panter *et al.* 2015) followed 469 adult commuters who lived within 30km of Cambridge and worked in areas that could be reached by bus. The median distance from worker's homes to their places of employment was 8km. The majority of participants had at least one car in their household. The study showed that exposure to the busway was associated with a significantly greater likelihood of an increase in weekly cycle commuting time, and an increase in the overall time spent in active commuting among the least active commuters at the baseline level. Participants living 4km from the busway were 34% more likely to have increased their cycle commuting time than those living 9km away. Among those who reported more cycle commuting after the busway opened compared to before, the mean increase was 86.6 minutes per week, or more than half the recommended weekly activity. The study shows that providing new sustainable transport infrastructure was effective in promoting an increase in active commuting. Some caution should be applied when generalising the results of this study to the Dublin context due to the very high prevalence of cycling in Cambridge. However, like Cambridge, Dublin has above average levels of health and affluence.

It is reasonable to assume, based on the above evidence, that the Proposed Scheme will facilitate increased levels of physical activity among the residential population within the study area. School children may be particular beneficiaries of this new infrastructure due to the presence of schools. The likely level of increase in physical activity to be gained is uncertain but could contribute to approximately 30% to 50% of weekly recommended physical activity on the assumption that the studies can be generalised to this area of Dublin. The health outcomes associated with increased physical activity are:

- Reduced risk of stroke and heart disease;
- Reduced risk of hypertension;

- Reduced risk of type 2 diabetes;
- Reduced risk of eight types of cancer;
- Reduced risk of depression;
- Improved cognitive function;
- Reduced risk of dementia;
- Improved musculoskeletal health;
- Improved weight management; and
- Improved mental wellbeing.

While there is strong scientific evidence of associations between increased physical activity and the above health outcomes; the degree to which levels of physical activity will increase among the population in the study area, together with the uncertainty over how much time being physically active will increase, means that the overall potential impact on health outcomes will be Positive and Significant in the Long-term. This is on the basis that some individuals are likely to change their behaviour and accrue the recommended weekly levels of physical activity by building this into their regular commute, but it is not certain that these health benefits will be accrued across the general population in the study area. Positive mental wellbeing and weight management health outcomes are likely to be achievable in the short term through increased physical activity levels, whereas the other health conditions identified above are likely to be longer term outcomes.

11.4.4.2 Health Impacts of Changes to Noise and Air Quality

The air dispersion modelling assessment has found that the Proposed Scheme will be neutral overall in the study area. The number of receptors where an exceedance of the NO_2 limit value is predicted to reduce from 14 in the Do Minimum scenario to 13 in the Do Something Scenario as a result of the Proposed Scheme, so is similar to the baseline. In 2043 all receptors are expected to have ambient air quality in compliance with the ambient air quality standards for the Do Something (and Do Minimum) scenario. For PM_{10} and $PM_{2.5}$, the Proposed Scheme will have a neutral overall impact as all receptor locations are expected to have a negligible change (see Section 7.4.4.3 in Chapter 7 (Air Quality)). In both the Do Minimum and Do Something scenarios, the predicted annual average concentrations of $PM_{2.5}$ (the air pollutant of greater health concern), are predicted to exceed the WHO fourth interim value of 10µg/m^3 and guideline value of 5µg/m^3 but are all under the the relevant national air quality limit value. It should be noted that the air quality assessment considers only the most affected receptors, so the modelling results do not reflect the degree to which the overall population would be exposed to impacts on air quality. The air quality assessment assesses the impacts associated with the Operational Phase traffic emissions will overall be neutral and long-term. It is not considered likely that any measurable changes in health outcomes could be attributable to the Proposed Scheme. Consequently, the impact on health from air quality is assessed as Neutral, Moderate and Long-term.

Chapter 9 (Noise & Vibration) identifies the following potential operational noise impacts:

- Traffic noise along the Proposed Scheme itself (opening year and design year);
- Traffic noise on the surrounding road network (opening year and design year); and,
- Noise at new bus stops.

For traffic noise along the Proposed Scheme and the surrounding road network, a mixture of positive slight impacts to negative, not significant impacts are predicted for both the opening year (short-term) and design year (long-term). Noise at new bus stops is predicted to be negative, not significant, long-term (See Section 9.5.2 of Chapter 9, Noise and Vibration). The parameter used in the noise assessment is the $L_{Aeq,\ 16hr}$ which is the most appropriate to capture the traffic related noise effects of the Proposed Scheme. This parameter also aligns with the thresholds for noise management set within the Dublin Agglomeration Environmental Noise Action Plan 2018 – 2023 (DCC *et al*. 2018). To support this health assessment, L_{den} outputs have also been provided (see Appendix A9.2 Noise & Vibration Results in Volume 3 of this EIAR) (see Section 9.4.3 of Chapter 9 (Noise & Vibration) for further information). This assessment considers the implications for health outcomes as described in the WHO Environmental Noise Guidelines, (WHO, 2018). As discussed in section 11.2.2 of this chapter, the WHO acknowledges that the Environmental Noise Guidelines cannot be reasonably achieved at every individual residence and so the assessment of the impact on health presented in this chapter considers the overall impact

on the population. Section 9.4.5 of Chapter 9 (Noise & Vibration) should be referred to for information on specific locations which would experience notable noise impacts.

No impact on night-time traffic noise is anticipated from the Proposed Scheme as traffic modelling indicates that there is no significant redistribution of traffic during the night. Therefore, there would be no likely impact on sleep disturbance.

Under normal conditions a 3 dB change is the minimum change which is perceptible to people, while a 1dB change is the minimum change which is perceptible in controlled conditions. The results of the assessment of noise from traffic redistribution in Appendix A9.2 show the predicted changes in L_{den} at modelled roadside locations. An Indirect, Positive, Imperceptible, Long Term to Negative, Not Significant to Slight, Long Term change in traffic noise levels will occur along the surrounding road network outside of the Proposed Scheme. Whilst an element of traffic re-distribution will occur during daytime periods, the resultant noise impacts are Negative, Not Significant to Slight and Long Term.

On this basis the health outcomes associated with noise from the Proposed Scheme are anticipated to be Neutral and Long-term.

11.4.4.3 Impacts on Use of Outdoor Spaces, Community Severance and Health

Some streets would benefit from a reduction in through-traffic, while for others there would be an increase in traffic, as traffic is redistributed away from the Proposed Scheme corridor. Chapter 6 (Traffic & Transport) reports that there would be a reduction in general traffic flows along the Proposed Scheme and assesses this as a positive, slight and long-term effect. It assesses a negligible effect due to redistributed traffic on the surrounding road network. The Proposed Scheme would improve the pedestrian environment along the bus corridor, giving people more time to interact. The transition from reliance on cars, to the use of a more reliable public transport service would help to facilitate more social interaction as people would gather at bus stops or have the opportunity to converse on buses. Furthermore, the proposals to improve the quality of the street environment, such as tree planting, creation of rest areas, paved areas, and areas of ornamental planting, may support more social interaction. On balance it is anticipated that there would be a greater level of social interaction facilitated by the Proposed Scheme than inhibited by the proposals.

Studies show that there is an inverse relationship between the average number of social contacts people in a residential street have and the volume of traffic (see Section 11.3.4 for supporting evidence). Reduced through-traffic would reduce actual and perceived community severance and support more social interaction. There are limited studies that demonstrate measurable short or long-term health outcomes from reduced community severance. However, there is substantial evidence of the importance of social contacts to improved health outcomes (Mindell and Karlsen 2012).

On the above basis, the potential impact on population health will be Positive, Moderate and Long-term.

11.4.4.4 Health Impacts of Improved Journey Times

It is predicted that total bus journey times will improve by between 10% and 19% during the AM and PM Peak hours of the 2028 Opening Year and 2043 (fifteen years after the Opening Year) (see Chapter 6 (Traffic & Transport)). Health benefits of this would include reduced stress for commuters as they have a more efficient journey and certainty over journey time, and the time saving may allow more time for health promoting activities such as seeing family and friends, exercise, sleeping and healthy food preparation. Furthermore, a shorter period of time travelling would also reduce the length of time passengers are exposed to air pollutants (Gulliver and Briggs 2004). The associated health outcomes are judged likely to be beneficial. The overall potential impact on human health will be Positive, Moderate in the Long-term. This is on the basis that the time savings will be noticeable for some individuals, but it is not clear that this would lead to improved population health outcomes.

11.4.4.5 Impacts on Access to Health services

The Proposed Scheme will not change the physical ability to access healthcare services. However, the predicted improvements in public transport journey times (described in Section 11.4.4.4) and reliability would make public transport a much more convenient choice for travelling to healthcare services and would reduce the likelihood in missing appointments due to traffic congestion delays. The inclusion of bus priority measures would also provide more efficient and reliable routes for emergency ambulances, and so could contribute to improved survival rates for certain emergency health conditions. The improved walking and cycling facilities would also support safer and

more convenient journeys to healthcare by active travel modes. It is judged that the overall potential impact on access to healthcare will be Positive, Significant in the Long-term, on the basis that improved journey times would provide for a more equitable transport experience, including for those without access to a car.

11.4.4.6 Impacts on Health Inequalities

The Proposed Scheme may help to reduce inequalities by improving access to employment for those dependent on public transport. Groups that would benefit most are the socially disadvantaged and some people with disabilities, noting that there is often an interrelationship between disability and deprivation, and that car ownership among disabled people is lower. No aspects of the Proposed Scheme that could have a likely significant contribution to a widening of health inequalities have been identified.

The Proposed Scheme has been designed following the guidelines in Building for Everyone – A Universal Design Approach (Centre for Excellence in Universal Design 2020). In general, the Proposed Scheme is likely to improve the street environment meeting current Universal Design good practice standards or at least make it no worse than the current situation. An accessibility audit determined that the majority of footways along the existing route were in a reasonable state of repair and the majority of crossings already have dropped kerbs and tactile paving. However, the Proposed Scheme is expected to address some gaps in existing provision, as well as upgrade some pedestrian and cycle routes to a better standard (segregated instead of delineated with painted white lines). Assuming these design measures are correctly installed, the urban environment would be easier and safer for a wider variety of pedestrians, including the visually impaired, wheelchair users and people with mobility difficulties, parents with young children and pushchair users. This would help to reduce health inequalities in terms of accessibility in the urban environment, particularly for people with disabilities.

The introduction of a reliable public transport corridor, with improved accessibility for public transport users and pedestrians, would have a likely positive effect in the short to medium term for reducing health inequalities associated with accessibility for disabled people in particular. The potential impact will be Positive, Moderate and Medium-term, on the basis that the Lucan study area has a much smaller proportion of disabled residents and lower levels of deprivation than average for Dublin, so the benefits may influence health inequalities at a modest level. The impact is assessed as medium-term on the basis that maintenance will be required to maintain the performance of infrastructure for accessibility over time, and that accessibility design standards may also change over the long-term.

It is possible that adolescents and children may also benefit from the Proposed Scheme, should more reliable bus journeys and an improved pedestrian and cycling environment support more independent mobility for young people. Concern over road safety can deter parents from allowing their children independent mobility, which limits opportunities for social interaction and exercise. Independent mobility, as well as making an important contribution to overall physical activity, provides additional benefits to children by promoting their social, cognitive and emotional development (Kytta 2004 in Veitch *et al.* 2017). It is uncertain the degree to which the Proposed Scheme will impact on children's independent mobility, but there are a number of schools and colleges in the study area, and so the improved conditions are likely to benefit some children. On this basis, the potential impact on reducing health inequalities relating to independent mobility will be Positive, Moderate and Long-term. The benefit may increase over time, should social norms concerning cycling and travel change.

The Proposed Scheme will likely reduce health inequalities for pedestrians and cyclists. In a car-dominated environment, walking and cycling generally carries a five to 10 times higher risk of injury per kilometre travelled than driving a car (Elvik 2009). There are several studies that show that there is a 'safety in numbers' principle whereas, when rates of active travel increase, the rates of pedestrian, cyclist and overall road traffic injuries have been observed to decline. There is good evidence that rates of cycling increase where active travel infrastructure is provided. The Proposed Scheme will not only introduce greatly improved active travel infrastructure, but will also reduce traffic along the route, further increasing safety for pedestrians and cyclists. On the basis that this will benefit active travellers for a key route into Dublin, the potential impact for health inequalities relating to injuries from vehicle collisions involving pedestrians and cyclists will be Positive, Very Significant and Long-term.

11.4.4.7 Other Environmental Hazards

Chapter 13 (Water) and Chapter 14 (Land, Soils, Geology & Hydrogeology) have not reported any residual impacts from the Operational Phase that are of a nature that could be linked to likely significant effects on human

health outcomes. On this basis, the potential impact of other environmental hazards associated with construction of the Proposed Scheme on population health will be Neutral.

11.4.4.8 Risk of Communicable Diseases

As set out in Section 11.3.6, the experience of the COVID-19 pandemic has shown how health protection measures, such as use of face coverings can help manage the risk of transmission of communicable diseases. It is known that the winter of 2020/2021 showed a record low level of influenza and other respiratory viruses other than COVID-19. It is very likely that this is attributable to a public health measures taken because of COVID-19. Some of these such as sanitisations and masks may bring benefits even when COVID-19 is no longer an issue.

The Proposed Scheme will facilitate improved public transport journeys, as well as improved opportunities for walking and cycling (which support journeys in a socially distanced environment). However, it would not in itself introduce a perceptible change in risk, since it is providing built infrastructure only, and public transport services, walking and cycling are already present within the Dublin baseline. Better air quality due to use of public transport as opposed to private cars has potential to benefit respiratory health and could reduce the risk of COVID-19 and other respiratory illnesses. The overall effect of the Proposed Scheme is considered to be Neutral and Long-term in relation to risk of communicable diseases.

11.4.4.9 Summary of Potential Operational Phase Impacts

Table 11.7 provides a summary of the assessment of impacts described in Section 11.4.4.1 to Section 11.4.4.8. The pathways to the greater predicted health effects are permanent changes in transport provision and access which would bring multiple pathways associated with health improvement such as opportunities for improved physical activity (active travel), reduced air pollution, opportunities for more equitable transport and access to services, and opportunities for more social interaction. Health effects such as reduced burden of disease associated with greater physical activity, access to health services and improved safety for vulnerable road users are expected to be significant.

Table 11.8: Summary of Potential Operational Phase Impacts

Assessment Topic	Associated Health Outcomes	Potential Impact
Increased physical activity from improvements to walking and cycling conditions	• Reduced risk of stroke and heart disease; • Reduced risk of hypertension; • Reduced risk of type 2 diabetes; • Reduced risk of eight types of cancer; • Reduced risk of depression; • Improved cognitive function; • Reduced risk of dementia; • Improved musculoskeletal health; • Improved weight management; and • Improved mental wellbeing.	Positive and Significant and Long-term – on the basis that some individuals are likely to change their behaviour and accrue the recommended weekly levels of physical activity by building this into their regular commute, but it is not certain that these health benefits will be accrued across the general population in the study area.
Air quality impacts	• Cardiovascular disease • Exacerbation of asthma • Exacerbation of respiratory conditions (e.g. bronchitis and pneumonia)	Neutral, Moderate and Long-Term impacts. Impacts are likely to be in line with baseline health trends relating to air quality.
Noise impacts from Proposed Scheme Core Bus Corridor, bus stops and redistribution of traffic on the wider road network	• Annoyance • Sleep disturbance • Cardiovascular risk	Neutral, Long-term on the basis that the vast majority of modelled locations would experience an imperceptible change in noise.

Assessment Topic	Associated Health Outcomes	Potential Impact
Impacts on social use of space and community severance	• Levels of social interaction (and associated outcomes such as mental health and wellbeing and overall life expectancy) • Levels of physical activity (and associated outcomes – see above for physical activity)	Positive, Moderate and Long-term – on the basis that improved opportunities for social interaction would be greater than those routes that would experience an increase in general traffic.
Improved journey times	• Reduced stress/improved mental wellbeing from reliable journey times/control • Outcomes associated with having additional time for health promoting opportunities such as exercising, socializing, sleeping and preparing healthy food (speculative)	Positive, Moderate and Long-term - on the basis that the time savings will be noticeable for some individuals, with benefits to their wellbeing, but it is not clear that this would lead to improved population health outcomes.
Impact on access to health services	• Emergency health care • General health outcomes associated with access to healthcare	Positive, Significant in the Long-term, on the basis that improved journey times would provide for a more equitable transport experience, including for those without access to a car. It would also improve journey reliability for emergency ambulances which could improve survival rates for some emergency health conditions.
Impacts of Health Inequalities: Disability and deprivation	• Reduced health inequalities relating to accessibility.	Positive, Moderate and Medium-term, on the basis that improved journey times would provide for a more equitable transport experience, including for those without access to a car.
Impacts of Health Inequalities: Children and adolescents	• Reduced health inequalities relating to independent mobility	Positive, Moderate and Long-term – it is uncertain the degree to which the Proposed Scheme will impact on children's independent mobility, but there are a number of schools in the study area, and so the improved conditions are likely to benefit some children.
Impacts of Health Inequalities: Pedestrians and cyclists	• Reduced health inequalities relating to road traffic injuries and deaths	Positive, Very Significant and Long -term - there is good evidence that rates of cycling increase where active travel infrastructure is provided, and this is a key route into Dublin.
Other environmental hazards (water pollution, flood risk, ground contamination)	• Various	Neutral - No residual impacts from other environmental factors have been identified as likely to affect health.
Risk of communicable diseases	• Various	Neutral in relation to risk of communicable diseases in the Long-term – the Proposed Scheme provides infrastructure but the public transport, walking and cycling can already occur in the baseline, so in itself does not alter the risk of transmission. There is speculative evidence that reductions in air pollution may improve respiratory health and resilience to respiratory diseases.

Notes:

'Annoyance' is defined as a feeling of displeasure, nuisance, disturbance or irritation caused by a specific sound (Ouis 2001 in WHO 2018). In the current WHO noise guidelines, 'annoyance' refers to long-term noise annoyance (WHO 2018).

For associated health outcomes the following terminology is applied where there is not a strong body of scientific evidence reporting good evidence of association between the health determinant and health outcome:

- *Emerging – a growing area of scientific research indicating evidence of association between the health determinant and health outcome but as yet not a strong body of evidence from a variety of studies / contexts; and*
- *Speculative – there is currently a lack of good quality scientific research into associations between the health determinant and health outcome*

11.5 Mitigation and Monitoring Measures

11.5.1 Construction Phase

Mitigation for Construction Phase related traffic impacts are set out in Section 6.5 (Mitigation and Monitoring Measures) of Chapter 6 (Traffic & Transport) and Appendix A5.1 CEMP in Volume 4 of this EIAR.

Measures will also be developed by the appointed contractor in the final Construction Traffic Management Plan to provide safe access for pedestrians and to help protect cyclists against an increased risk of collision with vehicles in areas of works and traffic management. Segregated lanes or diversions down quiet streets should be

considered. Pedestrians will be protected through various measures such as segregated diversions around areas of works, clear signage, removal of obstacles and provision of safe crossing points.

Access to all hospitals will be maintained and the Construction Traffic Management Plan will set out measures to minimise any delay for emergency response vehicles, specifically ambulances, in accessing the facilities.. This mitigation is expected to reduce the risk of delay to be comparable to baseline conditions where existing traffic conditions can cause delays to emergency access. In advance of construction works in the vicinity of hospitals, the appointed contractor will liaise with them where necessary to inform them of the proposed construction traffic management arrangements.

Mitigation for construction related air quality impacts are set out in Section 7.5. (Mitigation and Monitoring Measures) of Chapter 7 (Air Quality) and the appointed contractor will liaise with the Hermitage Clinic in advance of the commencement of construction works to inform them of the proposed construction management arrangements.

Mitigation for construction related noise and vibration impacts are set out in Section 9.5 in Chapter 9 (Noise & Vibration). Of relevance, is that the appointed contractor will comply with the recommendations of British Standard BS 5228–1 Code of practice for noise and vibration control on construction and open sites (British Standard Institute 2014a) and S.I. No. 241/2006 - European Communities Noise Emissions by Equipment for Use Outdoors (Amendment) Regulations 2006.

Mitigation for adverse psychosocial responses to the Construction Phase will include providing the public with sufficient information to enable people to plan their days, journeys and activities around the construction works and take control of their options to some extent. The appointed contractor will put in place a Communications Plan in accordance with NTA requirements. The Plan will provide a mechanism for members of the public to communicate with the NTA and the appointed contractor, and for the NTA and the appointed contractor to communicate important information on various aspects of the Proposed Scheme to the public. This will include timely communication to the local community on the planned work activities, timings and traffic management. These requirements are set out in the CEMP (see Appendix A5.1 in Volume 4 of this EIAR).

No specific monitoring measures are considered necessary for human health over and above monitoring measures identified elsewhere in this EIAR.

11.5.2 Operational Phase

Mitigation and monitoring measures in Chapter 6 (Traffic & Transport) identify that impacts to general traffic and parking / loading are embedded into the Proposed Scheme, as outlined in Chapter 4 (Proposed Scheme Description). The Proposed Scheme will result in positive impacts for walking, cycling, bus and people movement and so no mitigation and monitoring measures are required for traffic and transport.

As set out in the mitigation and monitoring measures in Chapter 7 (Air Quality), no specific Operational Phase mitigation or monitoring measures for air quality are required as all ambient air pollutants will remain in compliance with the ambient air quality standards and the Proposed Scheme will have a generally neutral impact on air quality.

As set out in the mitigation and monitoring measures in Chapter 9 (Noise & Vibration), the range of noise level changes and overall noise levels calculated for traffic noise do not require any specific noise mitigation measures to be incorporated into the Proposed Scheme. No further noise mitigation measures are proposed for the new bus stops, as the overall noise context associated with the bus corridors is expected to improve with the transition of the bus fleet to electric and hybrid vehicles between the Opening Year (2028) and the Design Year (2043).

No significant negative health effects have been identified as a result of the Operational Phase of the Proposed Scheme, and therefore, no further mitigation measures are required.

No specific monitoring measures are considered necessary for human health over and above monitoring measures identified elsewhere in this EIAR.

11.6 Residual Impacts

11.6.1 Construction Phase

With the exception of emergency access to the Hermitage Medical Clinic, the residual health impacts relating to the Construction Phase would be the same post-mitigation since the health assessment reported in Section 11.4 takes account of residual air, noise and traffic impacts following the application of mitigation for those topics. In the case of emergency access to the Hermitage Medical Clinic, it is anticipated that the potential impact of delays to emergency access will be reduced through specific measures to be set out in the Construction Traffic Management Plan. The traffic modelling for the Proposed Scheme indicates that it is not likely to cause significant issues of congestion on the wider traffic network, meaning the risk of the Proposed Scheme contributing to delays to emergency access is low during the Construction Phase. On this basis it is predicted that the effect on emergency healthcare outcomes will reduce to Negative, Slight, Short-term. No significant residual impacts on human health were identified due to construction of the Proposed Scheme.

11.6.2 Operational Phase

Three issues were assessed as likely to be associated with significant residual impacts on human health, all of which were considered positive.

Lack of regular physical activity is a leading cause of chronic disease and premature deaths. The Proposed Scheme will improve opportunities and convenience for walking and cycling, which will support many people in the study area in achieving recommended levels of weekly physical activity, for example as part of an active travel commute to work or education. It will also increase safety and the perception of safety for pedestrians and cyclists, who are more vulnerable to injury and mortality from traffic collisions. Furthermore, by redressing the balance between private car-use and other forms of transport, the Proposed Scheme will improve public transport journey times and reliability, as well as introduce greatly improved active travel infrastructure. This will provide for a more equitable transport experience, including for those without access to a car.

The Proposed Scheme is expected to have a significantly positive contribution to health outcomes related to increased physical activity, equitable access to services and improved safety for vulnerable road users.

The significant positive impacts which are expected to arise in the operational phase fully align with the relevant objectives of the Proposed Scheme identified in Section 11.1.

Table 11.8: Summary of Operational Phase Significant Residual Impacts

Assessment Topic	Significant Residual Impact
Increased physical activity from improvements to walking and cycling conditions	Positive and Significant and Long-term
Impacts on access to health services	Positive, Significant in the Long-term
Impacts of Health Inequalities: Pedestrians and cyclists	Positive, Very Significant and Long -term

11.7 References

Appleyard, D.(1981). Livable Streets. University of California Press.

AsIAm, (2015). AsYouCan – Public Transport. [Online]. Available at https://asiam.ie/wp-content/uploads/2015/04/transport_final.pdf

AsIAm, (2021). https://asiam.ie/ [website]

Babisch, W., (2006). Transportation noise and cardiovascular risk: updated review and synthesis of epidemiological studies indicate that the evidence has increased. Noise Health, 8 (2006), pp. 1-29

Ballester, F., Medina, S., Boldo, E., Goodman, P., Neuberger, M., Iñiguez, C., Künzli, N. and on behalf of the Apheis network, (2008). Reducing ambient levels of fine particulates could substantially improve health: a mortality impact assessment for 26 European cities, Journal of Epidemiology and Community Health, 62: 98-105.

Bassett D, Pucher J, Buehler R, Thompson D and Crouter S. (2008). Walking, cycling, and obesity rates in Europe, North America and Australia. Journal of Physical Activity and Health. Vol. 5, pp795-814.

Besser, L., Dannenberg, A. (2005) Walking to public transit. Steps to help meet physical activity recommendations, American Journal of Preventive Medicine, 29(4): 273-280.

Bluhm, G.L., Berglind, N., Nordling, E., Rosenlund, M., (2007). Road traffic noise and hypertension. Occup Environ Med, 000 (2007), pp. 1-6

Bonham, J. Cathcart, S., Petkov, J., Lumb, P. (2007). Safety in numbers: A strategy for cycling? University of South Australia, Adelaide.

Braveman, P. and Gottlieb, L. (2014). The social determinants of health: it's time to consider the causes of the causes. Public Health Rep. 2014 Jan-Feb;129 Suppl 2(Suppl 2):19-31. doi: 10.1177/00333549141291S206. PMID: 24385661; PMCID: PMC3863696.

British Medical Association. (2012). Healthy transport = Healthy lives. Available at: https://www.bma.org.uk/collective-voice/policy-and-research/public-and-population-health/transport

British Standard Institute (2014). BS 5228–1 Code of practice for noise and vibration control on construction and open sites

Carlin A., Murphy, M.H., & Gallagher, A.M.. (2015). Do interventions to increase walking work? A systematic review of interventions in children and adolescents. Sports Med, 46 (5), 515-530.

Centre for Excellence in Universal Design, (2020). Building for Everyone – A Universal Design Approach. National Disability Authority. [Online] Available at: http://universaldesign.ie/Built-Environment/Building-for-Everyone

Chen and Hoek (2020). Long-term exposure to PM and all-cause and cause-specific mortality: a systematic review and meta-analysis. Environ Int. 143:105974. doi: 10.1016/j.envint.2020.105974.

Clark C, Paunovic K. (2018). WHO Environmental Noise Guidelines for the European Region: A Systematic Review on Environmental Noise and Cognition. Int J Environ Res Public Health. 2018 Feb 7;15(2):285. doi: 10.3390/ijerph15020285. PMID: 29414890; PMCID: PMC5858354.

CSO (2016). 2016 Census

CSO (Central Statistics Office), (2018). Statistical Product – Deaths Occurrences [Online] Available from https://data.cso.ie/table/VSD10

CSO (Central Statistics Office), (2019a). Mortality Differentials in Ireland 2016-2017. [Online] Available from https://www.cso.ie/en/releasesandpublications/in/mdi/mortalitydifferentialsinireland2016-2017/

CSO, (2019b). The Wellbeing of the Nation (2017). [Online] Available from https://www.cso.ie/en/releasesandpublications/ep/p-wbn/thewellbeingofthenation2017/hlt/

CSO, (2019c). Census 2016 Summary Results – Part 2, Chapter 8, Travel Patterns and Car Ownership. [Online]. Available at: https://www.cso.ie/en/csolatestnews/presspages/2017/census2016summaryresults-part2/

CSO, (2019d). National Travel Survey 2016: Key Findings. Table 1.5. [Online] Available at https://www.cso.ie/en/releasesandpublications/ep/p-nts/nts2016/keyf/

Dahlgren G and Whitehead M, (1991). What Can Be Done About Inequalities in Health? Lancet. 1991 Oct 26; 338(8774): 1059-1063.

Dempsey S., Lyons S., Nolan A., (2017). High Radon Areas and lung cancer prevalence: Evidence from Ireland. Journal of Environmental Radioactivity 182 (2018) 12–19.

Department of Health (2019). A Framework for Improved Health and Wellbeing 2013 – 2025

Department of Transport, Tourism and Sport, (2019). Temporary Traffic Measures and Signs for Roadworks. [Online] Available at: NEW - Temporary Traffic Management Suite | Trafficsigns.ie

D'Hease, S., Vanwollegham, G., Hinckson, E., De Bourdeauhuij, I., Deforche, B., Van Dyck, D., & Cardon, G. (2015). Cross-continental comparison of the association between the physical environment and active transportation in children: A systematic review. IJBNPA, 12 (145), DOI 10.1186/s12966-015-0308-z.

Disability Federation of Ireland, (2005). Disability and Population Health Discussion Paper. Dublin. [Online] Available at https://www.disability-federation.ie/about/publications/disability-and-population-health-discussion-paper/

Disability Federation of Ireland, (2018). Disability Profile – Dublin City. [Online] Available at: https://www.disability-federation.ie/about/publications/disability-profile-dublin-city/

Disability Federation of Ireland, (2018). Disability Profile – South Dublin. [Online] Available at: https://www.disability-federation.ie/about/publications/disability-profile-south-dublin/

Dublin City Council, Fingal County Council and South Dublin City Council, (2018). Dublin Agglomeration Noise Action Plan 2018 – 2023. [Online] Available at: https://www.dublincity.ie/residential/environment/air-quality-monitoring-and-noise-control-unit/dublin-city-noise-maps/noise-action-plan

Dugundji, E.R;, Páez, A; Arentze, T.A; Walker, J. L; Carrasco, J.A; Marchal, F; Nakanishi, H (2011) Transportation and social interactions, Transportation Research Part A: Policy and Practice, Volume 45, Issue 4, 2011, pp 239-247, ISSN 0965-8564, https://doi.org/10.1016/j.tra.2011.01.001.

Elvik, R., (2009).The non-linearity of risk and the promotion of environmentally sustainable transport. Accident Analysis and Prevention, 2009. 41(4): p.849-55.

EPA (2022). Guidelines on the Information to be Contained in Environmental Impact Assessment Reports

Environmental Protection Agency (EPA), (2020). Radon Map, [Online] Available at https://www.epa.ie/radiation/radonmap/

ETC / ACM, (2019). European air quality maps for 2016 — PM10, PM2.5, ozone, NO2 and NOX spatial estimates and their uncertainties, Eionet Report ETC/ACM 2018/8, European Topic Centre on Air Pollution and Climate Change Mitigation [Online] Available at https://www.eionet.europa.eu/etcs/etc-atni/products/etc-atni-reports/etc-acm-report-2018-8-european-air-quality-maps-for-2016

European Commission (2017). Environmental Impact Assessment of Projects - Guidance on the Preparation of the Environmental Impact Assessment Report

European Environment Agency (EEA), (2019). Air quality in Europe — 2019 report. EEA Report no. 10/2019. ISSN 1977-8449. Available at https://www.eea.europa.eu/publications/air-quality-in-europe-2019

Franklin B.A., Brook R. and Pope III A, (2015). Air Pollution and Cardiovascular Disease. Current Problems in Cardiology. Vol 40, Issue 5, May 2015. Pp 207-238.

Grasser, G., Van Dyck, D., Titze, S., & Stronegger, W. (2013) Objectively measured walkability and active transport and weight-related outcomes in adults: a systematic review. International Journal of Public Health, 58 (4), 615-625.

Gulliver, J. and Briggs, D. J., (2004). Personal exposure to particulate air pollution in transport microenvironments, Atmospheric Environment, Volume 38, Issue 1, 2004, Pages 1-8, ISSN 1352-2310, https://doi.org/10.1016/j.atmosenv.2003.09.036.

Hart, J. and Parkhurst, G. (2011). Driven to excess: Impacts of motor vehicles on the quality of life of residents of three streets in Bristol UK. World Transport Policy and Practice, 17 (2). pp. 12-30. ISSN 1352- 7614.

Health Service Executive (HSE) Public Health Profile Working Group, (2015a). Health Profile 2015 Dublin South. HSE. Available from: http://www.lenus.ie/hse/bitstream/10147/584044/1/Dublin+South.pdf

Health Service Executive (HSE) Public Health Profile Working Group, (2015b). Health Profile 2015 Dublin City. HSE. Available from: https://www.lenus.ie/handle/10147/584037

Health Service Executive (HSE) Public Health Profile Working Group, (2015c). Health Profile 2015 Dublin Fingal. HSE. Available from http://www.lenus.ie/hse/bitstream/10147/584023/1/Dublin+Fingal.pdf

Health Protection Surveillance Centre. (2018). National Guidelines for the Prevention of Nosocomial Aspergillosis. HSE.

Holgate, ST, Koren, HS, & Maynard, RL (eds) (1999). Air Pollution and Health, Elsevier Science & Technology, San Diego.

IAIA/EUPHO, (2020). Human health: Ensuring a high level of protection. A reference paper on addressing Human Health in Environmental Impact Assessment as per EU Directive 2011/92/EU amended by 2014/52/EU. [Online] Available from: https://eupha.org/repository/sections/HIA/Human%20Health%20Ensuring%20Protection%20Main%20and%20Appendices.pdf

IEMA, (2020). Health Impact Assessment in Planning. Thought pieces from UK practice. [Online] Available at: https://www.iema.net/resources/news/2020/10/27/health-impact-assessment-in-planning

IPH (2009). Health Impact Assessment Guidance

IPH (2021). Health Impact Assessment Guidance for Ireland and Northern Ireland

Jacobsen, P, (2003). Safety in numbers: more walkers and bicyclists, safer walking and bicycling, Injury Prevention, 9: 205-209.

Joffe M and Mindell J, (2002). A framework for the evidence base to support Health Impact Assessment. J Epidemiol Community Health 2002;56:132–138

Joint Committee on Transport, Tourism and Sport, (2018). Accessibility of Public Transport for People with Disabilities. Available at: https://data.oireachtas.ie/ie/oireachtas/committee/dail/32/joint_committee_on_transport_tourism_and_sport/reports/2018/2018-11-14_accessibility-of-public-transport-for-people-with-disabilities_en.pdf

Kavanagh P, Doyle C, Metcalfe O, (2005). Health Impacts of Transport: A Review. Institute of Public Health in Ireland.

Krzyzanowski M, Kuna-Dibbert B, and Schneider J (eds), (2005). Health Effects of Transport-Related Air Pollution, World Health Organization.

Lamichhane, D. K., Leem, J.-H., Lee, J.-Y. & Kim, H.-C. (2015). A meta-analysis of exposure to particulate matter and adverse birth outcomes. Environ. Health Toxicol. 30, e2015011 (2015)

Lavin T, Higgins C, Metcalfe O, Jordan A, (2006). Health Impacts of the Built Environment, Institute of Public Health Ireland (IPH)

Lenus (2021). Available at: www.lenus.ie/

Liu, S., Krewski, D., Shi, Y., Chen, Y. & Burnett, R. T., (2007). Association between maternal exposure to ambient air pollutants during pregnancy and fetal growth restriction. J. Expo. Sci. Environ. Epidemiol. 17, 426–432

Lyon RM, Cobbe SM, Bradley JM, Grubb NR. (2004). Surviving out of hospital cardiac arrest at home: a postcode lottery? Emerg Med J. 2004 Sep;21(5):619-24. doi: 10.1136/emj.2003.010363. PMID: 15333549; PMCID: PMC1726412.

Marmot, M. (2010) Fair society, healthy lives: the Marmot Review: strategic review of health inequalities in England post-2010. ISBN 9780956487001

Mayou R, Bryant B. (2001). Outcome in consecutive emergency department attenders following road traffic accidents. Br J Psych 2001;179:528-34.

Mindell J. S. and Karlsen S., (2012). Community Severance and Health: What Do We Actually Know? Journal of Urban Health: Bulletin of the New York Academy of Medicine, Vol. 89, No. 2. doi:10.1007/s11524-011-9637-7

Mueller, N., Rojas-Rueda, D., Cole-Hunter, T., de Nazelle, A., Dons, E., Gerike, R., Götschi, T., Panis, L.I., Kahlmeier, S., & Nieuwenhuijsen, M. (2015). Health impact assessment of active transportation: a systematic review. Preventive Medicine, 76, 103-114.

NCRI, (2011). Lung Cancer Incidence, Mortality, Treatment and Survival in the Republic of Ireland: 1994-2008. National Cancer Registry, Cork, Ireland.

NCRI, (2017). National Cancer Registry Ireland: Cancer Factsheet Lung. [Online] Available at https://www.ncri.ie/sites/ncri/files/factsheets/lung.pdf

NRA, (2014). Good Practice Guide for the Treatment of Noise during the Planning of National Road Schemes. Available at: https://www.tii.ie/technical-services/environment/planning/Good_Practice_Guidance_for_the_Treatment_of_Noise_during_the_Planning_of_National_Road_Schemes.pdf

NTA (2011). National Cycle Manual

Panter , J., Heinen, E., Mackett, R., Ogilvie, D. (2015). Impact of New Transport Infrastructure on Walking, Cycling, and Physical Activity. American Journal of Preventive Medicine. Vol 50, Issue 2, E45-E53. https://doi.org/10.1016/j.amepre.2015.09.021

Pedersen, M. et al., (2013). Ambient air pollution and low birthweight: a European cohort study (ESCAPE). Lancet Respir. Med. 1, 695–704

Pucher, J., Dijkstra, L. (2003) Promotion of safe walking and cycling to improve public health: lessons from the Netherlands and Germany. American Journal of Public Health, 93(3):1509-1516

R&D and Health Analytics Division and Chief Medical Officer's Division of the Department of Health, (2018). Estimating Prevalence of Autism Spectrum Disorders (ASD) in the Irish Population. Department of Health. Available at: https://www.gov.ie/en/publication/0cc791-reports-on-the-prevalence-of-autism-in-ireland-and-a-review-of-the-s/

Rajagopalan, S; Al-Kindi, S. G.; Brook, R. D. (2018). Air Pollution and Cardiovascular Disease. Journal of the American College of Cardiology, 23 October 2018, Vol.72(17), pp.2054-2070

Ritz, B., Wilhelm, M., Hoggatt, K. J. & Ghosh, J. K. C., (2007). Ambient air pollution and preterm birth in the environment and pregnancy outcomes study at the University of California, Los Angeles. Am. J. Epidemiol. 166, 1045–1052

Robinson, D. (2005). Safety in numbers in Australia: more walkers and bicyclists, safer walking and bicycling, Health Promotion Journal of Australia. Aug; 16(2):159-60.

Rudra, C. B., Williams, M. A., Sheppard, L., Koenig, J. Q. & Schiff, M. A., (2011). Ambient carbon monoxide and fine particulate matter in relation to preeclampsia and preterm delivery in western Washington State. Environ. Health Perspect. 119, 886–892

Simonsen, S. A., Andresen, M., Michelsen, L., Viereck, S., Lippert, F. K., & Iversen, H. K. (2014). Evaluation of pre-hospital transport time of stroke patients to thrombolytic treatment. Scandinavian journal of trauma, resuscitation and emergency medicine, 22, 65. https://doi.org/10.1186/s13049-014-0065-z

Slama, R., Morgenstern, V., Cyrys, J., Zutavern, A., Herbart, O., Wichmann, H-E., Heinrich, J. (2007). Traffic-related atmospheric pollutants levels during pregnancy and offspring's term birth weight: a study relying on a land-use regression exposure model. Environ. Health Perspect. 115, 1283–1292

Sobotova L, Jurkovicova J, Stefanikova Z, Sevcikova L, Aghova L, (2009). Community response to environmental noise and the impact on cardiovascular risk score, Science of the Total Environment, Vol 408, Issue 6, pp1264-1270

Social Finance. (2015). Investing to tackle loneliness. A discussion paper. Available at: https://www.socialfinance.org.uk/sites/default/files/publications/investing_to_tackle_loneliness.pdf

Steptoe, A., Shankar, A., Demakakos, P., Wardle, J., (2013). Social isolation, loneliness, and all-case mortality in older men and women. Proceedings of the National Academy of Sciences of the United States of America vol 110 no 15, 5797– 5801, doi: 10.1073/pnas.12196861

TomTom Traffic Index, (2019). [Online} Available at: https://www.tomtom.com/en_gb/traffic-index/ranking/

UITP, (2020). Public Transport is COVID-Safe. Available at: https://www.uclg.org/sites/default/files/policy_brief-ptiscovid-safe-uclg.pdf

UN Environment Programme (2018). https://www.unep.org/news-and-stories/blogpost/young-and-old-air-pollution-affects-most-vulnerable

van Kempen E.E.M.M., Kruize, H., Boshuizen, C., Ameling C.B., Staatsen, B.A.M., de Hollander, A.e.m., (2002). The association between noise exposure and blood pressure and ischaemic heart disease: a meta-analysis. Environmental Health Perspectives, 2002, 110:307–317.

Vardoulakis, S. Osborne, N., (2017). Air Pollution and Asthma. Archives of Disease in Childhood, 8 September 2018, Vol.103(9), p.813

Veitch, J.; Carver, A.; Salmon, J.; Abbott, G.; Ball, K.; Crawford, D.; Cleland, V.; and Timperio, A., (2017). What predicts children's active transport and independent mobility in disadvantaged neighborhoods? Health & Place 44 (2017) 103 – 109.

Wanner, M., Götschi, T., Martin-Diener, E., Kahlmeier, S., & Martin, B.W. (2012). Active transport, physical activity, and body weight in adults: a systematic review. American Journal of Preventive Medicine, 42 (5), 493-502.

Winckelmans E, Cox B, Martens E, Fierens F, Nemery B, Nawrot TS. Fetal growth and maternal exposure to particulate air pollution--More marked effects at lower exposure and modification by gestational duration. Environ Res. 2015 Jul;140:611-8. doi: 10.1016/j.envres.2015.05.015. Epub 2015 Jun 6. PMID: 26056995.

World Health Organization Europe, (n.d.). Wider determinants [Online] Available from http://www.euro.who.int/en/health-topics/health-determinants/social-determinants

World Health Organization, (1948). Constitution. Available at: https://www.who.int/governance/eb/who_constitution_en.pdf

World Health Organization, (2005). Air Quality Guidelines Global Update 2005. Particulate Matter, Ozone, Nitrogen Dioxide and Sulfur Dioxide. WHO 2006. [Online] Available at https://www.euro.who.int/en/health-topics/environment-and-health/air-quality/publications/pre2009/air-quality-guidelines.-global-update-2005.-particulate-matter,-ozone,-nitrogen-dioxide-and-sulfur-dioxide

World Health Organization, (2011). Burden of Disease from Environmental Noise. World Health Organization, Copenhagen.

World Health Organization, (2016). Radon and Health. [Online] Available at https://www.who.int/news-room/fact-sheets/detail/radon-and-health

World Health Organization Europe, (2018). Environmental Noise Guidelines for the European Region. [Online] Available at https://www.euro.who.int/en/health-topics/environment-and-health/noise/publications/2018/environmental-noise-guidelines-for-the-european-region-2018

World Health Organization (2021). Global Air Quality Guidelines: Particulate matter (PM2.5 and PM10), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide

Directives and Legislation

Council Directive 85/337/EEC of 27 June 1985 on the assessment of the effects of certain public and private projects on the environment

Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on ambient air quality and cleaner air for Europe

Directive 2014/52/EU of the European Parliament and of the Council of 16 April 2014 amending Directive 2011/92/EU on the assessment of the effects of certain public and private projects on the environment

S.I. No. 241/2006 - European Communities Noise Emissions by Equipment for Use Outdoors (Amendment) Regulations 2006.